ARMED FORCES CHEMICAL JOURNAL

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General Stubbs—new Chemical Chief (pg. 37).
Impressive field trial data on BW danger.
Backsighting the Chemical Corps—articles apropos 40th Anniversary.

NEW HONOR TO AN OLD FLAG (see pages 1 and 10)

SEPTEMBER—OCTOBER 1958

ARMED FORCES CHEMICAL ASSOCIATION

National Headquarters

408-410 Park Lane Building—2025 Eye Street, N.W.

WASHINGTON 6, D.C.

(Republic 7-6803)

The members of this Association, mindful of the vital importance to national defense of chemistry, allied sciences, and the arts derived from them, have joined together as a patriotic obligation to preserve the knowledge of, and interest in, national defense problems derived from wartime experience; to extend the knowledge of, and interest in, these problems; and to promote cooperative endeavor among its members, the Armed Services, and civilian organizations in applying science to the problems confronting the military services and other defense agencies, particularly, but not exclusively in fields related to chemical warfare. (From Art. II, AFCA Constitution.)

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POLICY

The fact that an article appears in this magazine does not indicate approval of the views expressed in it by any one other than the author. It is our policy to print articles on subjects of interest in order to stimulate thought and promote discussion; this regardless of the fact that some or all of the opinions advanced may be at variance with those held by the Armed Forces Chemical Association, National Officers, and the Editors. It is the responsibility of contributors, including advertisers, to obtain security clearance, as appropriate, of matter submitted for publication. Such clearance does not necessarily indicate indorsement of the material for factual accuracy or opinion by the clearing agency.

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USAR-(Ret.)

COVER PHOTO

Color of the First Chemical Regiment (inactive) recently transferred formally to the custody of the Chemical Corps School, Fort McClellan, Ala. Scarred tree trunk commemorates the Meuse-Argonne battlefield of World War I; the crest is a dragon, denoting fire and destruction; the motto is translated as "I rule with fire and smoke." (See article on page 10)

PHOTO CREDITS

Front cover and all other pictures identifiable as to origin, U. S. Army photos, except top of page 3, Seagall-Majestic, Baltimore. Not identifiable: page 3, lower left; page 18, and Milligan on page 22.

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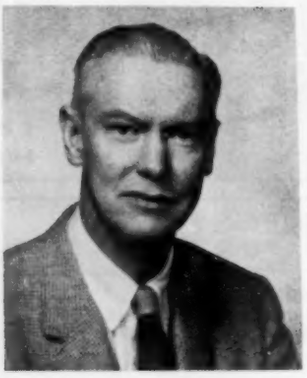
LETTERS MARK SUCCESS OF ANNUAL MEETING



Dr. W. F. Jackson

June 16, 1958

The Honorable Wilber M. Brucker
Secretary of the Army
Pentagon Building
Washington 25, D.C.
Dear Sir:

On behalf of the members of the Armed Forces Chemical Association and my meeting committee I wish to thank you for your assistance to our organization which resulted in wholehearted Army support of our Thirteenth Annual Meeting held in Atlantic City on June 5 and 6.

Major General John E. Theimer's talk opening the program for the services and Lieutenant General Arthur G. Trudeau's speech at the closing banquet were highlights of the meeting. The chiefs of the technical services or their deputies made excellent presentations in keeping with the theme, "The Role of the Army in Modern Warfare."

The technical services also did a marvelous job marshalling exhibits appropriate to the subject of the meeting. Their material, combined with the displays furnished by the Air Force, Navy and Marines, provided an unusually complete picture of modern military equipment with many references to its relationship with the chemical industry.

We are indebted to Colonel P. B. Melody of the Army Information Office and the T.L.O.'s of the technical services for their invaluable assistance in putting meat on the bones of our program. Lieutenant Colonel Timothy C. Williams of General Creasy's office was most helpful in maintaining effective liaison between my civilian committee and the military. The myriad details of scheduling exhibit arrivals and departures, providing transportation for speakers, and billeting service personnel were handled cheerfully and most efficiently by Colonel Theodore P. Gahan of First Army Headquarters.

It was an education in efficiency as well as a pleasure to work with your people on this meeting. All who attended now have an up-to-the-minute picture of the mission of the Army; also we have had an opportunity to renew acquaintance with old friends in the Service and to make new ones.

Thanks again to you for your backing and to the Army for its participation.

Sincerely yours,
Wendell F. Jackson
Vice President in Charge of Meetings
Armed Forces Chemical Association

SECRETARY OF THE ARMY

Washington

June 25, 1958

Dear Mr. Jackson:

Your recent letter regarding the annual meeting of the Armed Forces Chemical Association was received by me with considerable pleasure. I can assure you that the Army was only too happy to be of assistance to the Association.

All personnel who contributed to the success of the Association's meeting will be pleased to know that their efforts are so thoroughly appreciated. Accordingly, I am adding an expression of my own appreciation and calling your kind remarks to the attention of all who participated. They will be especially gratified to know that those who attended the meeting came away feeling they had an "up-to-the-minute picture" of the Army's mission. Thank you, indeed, for taking the time to write as you did.

With all good wishes,

Sincerely,
/s. Wilber M. Brucker
Wilber M. Brucker
Secretary of the Army

Mr. Wendell F. Jackson
Vice President in Charge of Meetings
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A. F. C. A. AFFAIRS

CONSULTING ENGINEER HEADS NEW CHESAPEAKE CHAPTER

Mr. S. Yeardley Smith, president of S. Yeardley Smith, Inc., Consulting Engineers of Baltimore, Md., is the president of the newly organized Chesapeake Chapter of A.F.C.A. The Chapter results from a recent merger of the former Army Chemical Center and Baltimore Chapters.

As a prelude to the merger action a joint meeting of the two separate groups was held recently at the Army Chemical Center with Colonel William J. Allen, then president of the ACC Chapter, presiding.

Highlight of the evening's program was a discussion by representatives of the Chemical Corps and industrial firms of problems faced by the military service and industrial concerns in the manufacture of Chemical Corps end items.

One of the major objectives of the Association is to achieve a better understanding by Industry of problems in the Armed Services, and spokesmen of both groups felt the panel discussion accomplished much toward fulfillment of this aim.

The proposed new constitution for the new chapter was also discussed and approved.

Colonel Lloyd E. Fellenz, commander of the Army Chemical Warfare Laboratories, was panel moderator. The members of the panel were: R. W. Baer (Continental Can), F. C. Lange (Continental Can), J. L. Traub (CmlC Materiel Command), Louis E. Garono (CmlC Engineering Command), W. S. Winslow (CmlC Engineering Command), Erich G. Schlaile (Diamond Alkali), and Edward Fogelman (Diamond Alkali).

GAILLARD RUMFORD OF ABBOTT IS NEW PRESIDENT OF MIDWEST

Mr. Gaillard Rumford, the new president of Midwest Chapter, was born in Jetmore, Kansas in 1912. He was graduated from Sterling (Kansas) College with a B.A. degree in chemistry and education. Advanced studies at Kansas State Agricultural College, University of Chicago and Lake Forest College included organic chemistry, chemical engineering, physical chemistry, catalytic hydrogenation, thermodynamics and electronics.

For the past 21 years Mr. Rumford has been employed in the Chemical Manufacturing Division of the Abbott Laboratories, North Chicago, Illinois. He is manager of the section which produces various barbiturates and anesthetics. During World War II he was in charge of the sulfa drug production.

Mr. Rumford has been active in the Armed Forces Chemical Association since 1950. He has been a consultant for the Department of Defense, namely, Chicago Procurement District, Army Chemical Corps, U.S. Army. He is also a member of the House Committee of the Chicago Section of the American Chemical Society. He resides at 338 Judge Avenue, Waukegan, Illinois.

MIDWEST HOLDS ELECTION; HEARS TALK ON AFRICA

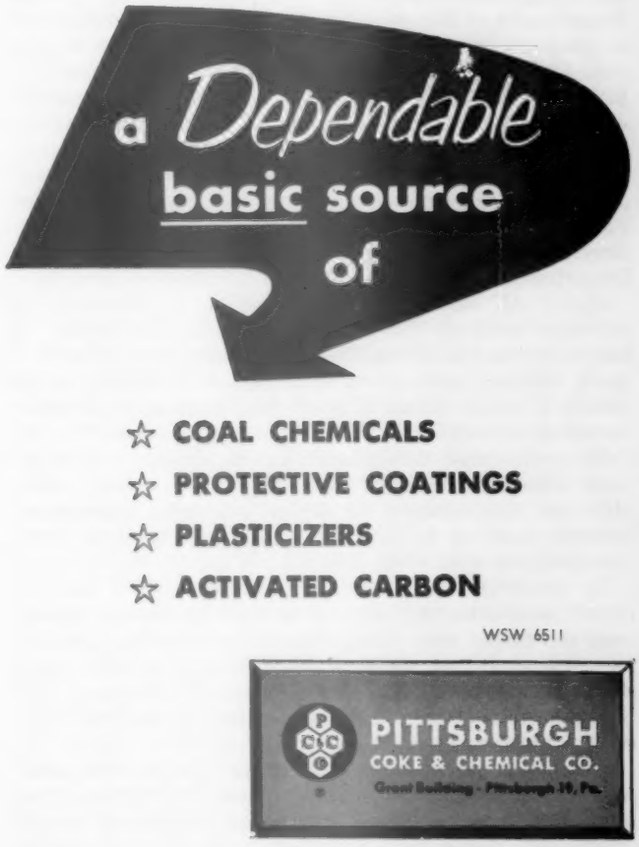
At the annual meeting of the Midwest Chapter held on April 29, at Stouffer's Prudential Plaza, the following officers of the Midwest Chapter were elected for the coming year:

President Gaillard Rumford, Abbott Laboratories; 1st Vice President, Hoyt M. Corley, Armour & Company; 2d Vice President, Col. Walter W. Kuehler, HQ, Fifth Army; Secretary-Treasurer, James J. Doheny, American Chemical Society; Directors: Lewis I. Terry, Dearborn Chemical Co., Maj. Lawrence M. Dellinger, Chicago Chemical Procurement District, Morton Hague, Henri, Hurst & McDonald; and Director ex officio, E. F. Binkerd, Armour & Company.

Dr. Brethold Schulz, the speaker after the business meeting, showed color movies of two trips which he has made through Africa in recent years. On both trips he traveled alone, in a small car or jeep, and obtained extremly interesting pictures. Dr. Schulz spoke on a tour of Russia at the 1957 annual meeting, and was enthusiastically received at that time also.

Among the guests at the meeting were W. D. Wilkinson, of Los Angeles, who easily won the trophy as "member coming from the longest distance," and Phillip A. Ostrand, of the University of Illinois, Urbana, Illinois, A.F.C.A. Medal winner both in 1957 and 1958.

The Chairman of the Program Committee, Ray G. Sobottka, announced that a special cruise down the Illinois waterway, and back through the Calumet-Sag Channel, was scheduled for Saturday, September 6.



The following paper by Dr. Fothergill, eminent Detrick scientist in the field of biological warfare research, is printed here by permission of the American Medical Association. While addressed originally to a medical audience, it presents the potentiality of BW in such factual and readily understandable terms as to warrant its close reading and study by both military and laymen. The author cites results of some actual field trials showing agent dosage possibilities. Of much interest also is his discussion of the question of epidemics in relation to BW.—Editor

BIOLOGICAL WARFARE AND ITS DEFENSE

By LEROY D. FOTHERGILL, M.D.
Fort Detrick, Frederick, Maryland
Presented before The Medical Civil Defense Conference of the American Medical Association in San Francisco, California, on 21 June, 1958.

BIOLOGICAL warfare is the intentional use of living microorganisms or their toxic products for the purpose of destroying or reducing the military effectiveness of man. It is the exploitation of the inherent potential of infectious disease agents by scientific research and development, resulting in the production of BW weapons systems (Fothergill, 1957, 1958). Man may also be injured secondarily by damage to his food crops or domestic animals.

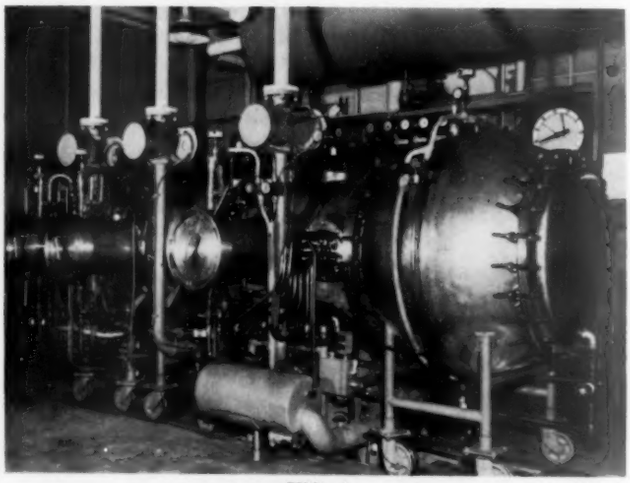
It was not until early in World War II that an officially planned program was devoted to research and development in biological warfare. This has continued to the present time as a recognized activity of the Department of Defense. Responsibility for carrying out a program was delegated to the Department of the Army which, in turn, assigned the operational responsibility to the Army Chemical Corps. The major portion of the research and development is conducted in permanent facilities at Fort Detrick in Frederick, Maryland. Close liaison is maintained with other Federal agencies having defensive responsibilities, including the Federal Civil Defense Agency, the U. S. Public Health Service, the Food and Drug Administration and the Department of Agriculture.

Biological warfare is considered to be primarily a strategic weapon. The major reason for this is that it has no quick-kill effect. The incubation period of infectious disease, plus a variable period of illness even before a lethal effect, render this weapon unsuitable for hand-to-hand encounter. A man can be an effective fighting machine throughout the incubation period of most infectious diseases. Thus, an enemy would probably use this weapon for attack on static population centers such as large cities. Our principal concern, therefore, is with *civil defense*.

An important operational procedure in BW for an enemy would be to create an aerosol or cloud of agent over the target area. This concept has stimulated much basic research concerning the behavior of biologic particulates, the pathogenesis of respiratory infections, the medical management of such diseases and defense against their occurrence.

The biological and physical properties of infectious particulates have been studied intensively during the past fifteen years. Much new equipment and many unique techniques have been developed for the quantitative exposure of experimental animals to aerosols of infectious agents contained in particulates of specified dimensional characteristics. Much information has been gathered relative to quantitative sampling and assessment techniques. Much of the older experimental work on respiratory infections was accomplished by very artificial procedures. The intranasal instillation of a fluid suspension of infectious agent in an anesthetized animal is far different from exposure through natural respiration, to aerosolized particulates.

This illustration shows some of this equipment currently in use at Fort Detrick.



Slide 1

I should like to say at this point that many of these aerobiological instruments and techniques have been developed to a remarkable state of technical perfection. To be able regularly to produce an aerosol such that each liter of air contains *one Pasteurella tularensis* organism and to be able to give each of a series of primates an *aerosol* dose of 10 to 25 organisms is a truly magnificent achievement.

THE importance of particle size in such aerosols has been thoroughly demonstrated. The natural anatomical and physiological defensive features of the upper respiratory tract, such as the turbinates of the nose and the cilia of the trachea and larger bronchi, are capable of impinging out the larger particles to which we are ordinarily exposed in our daily existence. Very small particles, however, in a size range of 1 to 4

microns are capable of passing these impinging barriers and entering the alveolar bed of the lungs. This area is highly susceptible to infection. The entrance and retention of infectious particles in the alveoli amounts almost to an intratissue inoculation. It would be well to review some of this information (Fothergill, 1956).

Extensive studies were conducted with the spores of anthrax. Young, Zelle and Lincoln (1946 a, b, c) published the results of early work conducted in the Detrick laboratories with this organism. Our English colleagues, Barnes (1947), Druett, Henderson, Pachman and Peacock (1953), and Harper and Morton (1953) published the results of their very comprehensive investigations. These studies showed that there is a very definite relationship between particle size and infectious dose of anthrax spores. When animals were exposed to particles in the 1.0 micron size range and compared with those exposed to particles of 12.0 microns in size, it was found that in the latter case the dose was 17 times as large as the former.

This is illustrated by some data of my associates, Day and Persichetti (1956), shown in the next slide.

EFFECT OF AEROSOL PARTICLE SIZE ON RESPIRATORY VIRULENCE OF BACILLUS ANTHRACIS SPORES FOR GUINEA PIGS

ORGANISM MEDIAN DIAMETER (μ)	RESPIRATORY LD_{50} (SPORES)	% PARTICLES <6μ	% SPORES IN PARTICLES <6μ
13.0	700,000	0.75	.02
12.0	660,000	1.90	0.75
8.2	358,000	40.0	15.0
6.8	221,000	45.0	28.0
4.9	74,000	98.0	95.0
2.7	60,500	100.0	100.0
1.5	22,800	100.0	100.0

Slide 2

No aerosol is completely homogeneous with respect to particle size. The data in this slide not only show the importance of particle size, but make it quite clear that infection is initiated only by those small particles that are populated with spores.

An even more striking relationship between infectious dose and particle size was shown to exist for *Brucella suis* in reports by Elberg and Henderson (1948), Harper (1955), and Druett, Henderson and Peacock (1956). In this case, the ratio between particle size and dose was 1.0 to 600 when particles of 1.0 and 12.0 microns in size were compared. In our own laboratories, similar relationships were found with this and other agents including *Coxiella burnetii, Pasteurella tularensis,* and the virus of Venezuelan equine encephalomyelitis. These data are summarized in the next slide.

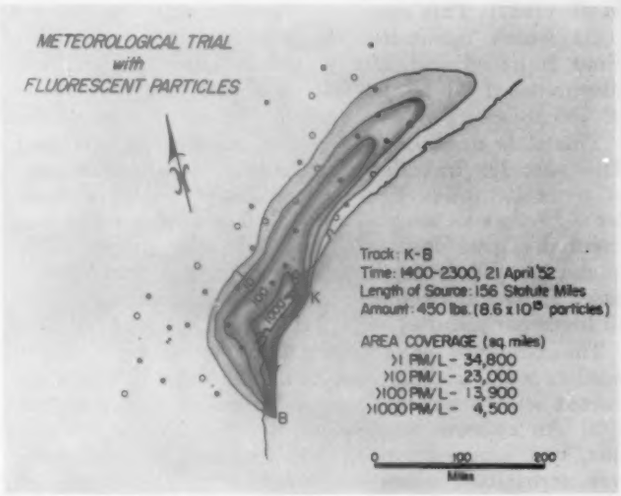
INFLUENCE OF PARTICLE SIZE ON RESPIRATORY VIRULENCE OF FOUR AGENTS FOR GUINEA PIGS*

PMD RANGE (μ)	AGENT RESPIRATORY LD_{50} VALUES			
	BACILLUS ANTHRACIS (SPORES)	PASTEURELLA TULARENSIS (BACILLI)	COXIELLA BURNETII (RICKETTSIA) (1)	VENEZUELAN EQUINE ENCEPHALOMYLITIS (VIRUS) (2)
0.3-1.5	23,000	2.48	1,000,000	20
4.0-6.5	221,000	6,500	52,700,000	19,000
8.5-13	700,000	19,500	$> 2.4 \times 10^9$	280,000

(1) DOSE IN GUINEA PIG IP ID_{50}

(2) DOSE IN MOUSE IC LD_{50}

Slide 3



Slide 4

Very enlightening studies of the penetration and retention of microparticles in the respiratory tract were conducted by Hatch (1948, 1950, 1954, 1956) and his associates under contract with Fort Detrick. They devised a special partitioning apparatus whereby the different fractions of respiratory air could be trapped and analyzed. The volunteer human subjects were placed in a respirator of the Drinker type, in order to control the respiratory cycle. They were exposed to uniformly sized particles of clay. It was found that approximately 25 per cent of particles of 1 to 3 microns in diameter were retained in the alveoli of the lungs. As the particle size increased, there was a smaller percentage reaching the alveoli and being retained. Moreover, retention in the alveoli was very poor with very small particles, i.e., those smaller than 0.5 microns in diameter.

IN considering BW defense one must recognize that a number of critical meteorological parameters must be met for an aerosol to exhibit optimum effect. For example, bright sunlight is rapidly destructive for living microorganisms suspended in air. There are optimal humidity requirements for various agents when airborne. Neutral or inversion meteorological conditions are necessary for a cloud to travel along the surface. It will rise during lapse conditions. There are, of course, certain times during the 24-hour daily cycle when most of these conditions will be met.

Certain other properties of small particles, in addition to those already mentioned in connection with penetration of the respiratory tract, are noteworthy in defense considerations. The smaller the particle the further it will travel downwind before settling out. An aerosol of such small particles, moreover, diffuses through structures in much the same manner as a gas. There may be a number of secondary effects resulting from diffusion through buildings such as widespread contamination of kitchens, restaurants, food stores, hospitals, etc. Depending on the organism, there may be multiplication in some food or beverage products, i.e., milk for

* For the reader who may not be familiar with symbols and abbreviations used in tables and illustrations:
small Greek letter μ stands for micron, 1/25,000 inch
LD_{50} = Lethal dosage for 50% of individuals exposed
IP = Intra-peritoneal
ID = Infective dosage
IC = Intra-cutaneous
PMD = Particles median diameter
PM/L = Particles of matter per liter (of air).—Editor

example. The secondary consequences from all this could be very serious and must be taken into consideration in planning for defense.

Something of the behavior of clouds of small particles can be illustrated by the following field trials:

In the first trial an inert substance was disseminated from a boat travelling some ten miles off shore under appropriately selected meteorological conditions. Zinc cadmium sulfide in particles of 2 microns in size were disseminated by techniques developed by Perkins et al. (1952). This material fluoresces under ultraviolet light which facilitates its sampling and assessment. Four hundred and fifty pounds of this material was disseminated while the ship was travelling a distance of 156 miles.

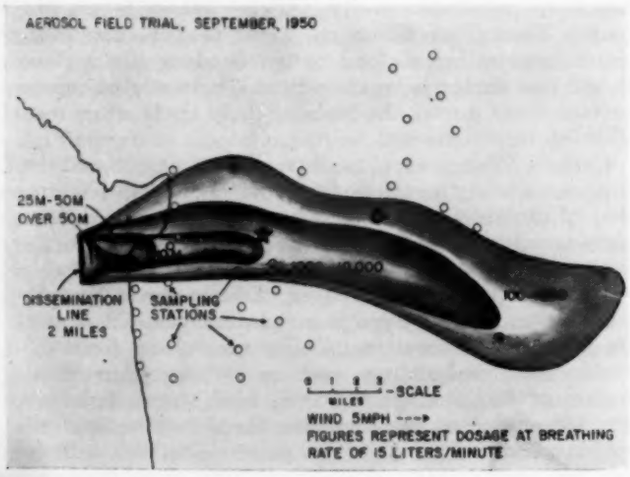
This slide describes the results obtained in this trial. The particles travelled a maximum detected distance of some 450 miles. From these dosage isopleths it can be seen that an area of over 34,000 square miles was covered. These dosages could have been increased by increasing the source strength which was small in this case. These values, multiplied by a breathing rate (i.e., 15 liters per minute) would represent the inhaled dose.

The behavior of a biological aerosol, on a much smaller scale, is illustrated by a specific field trial conducted with a non-pathogenic organism in September, 1950. An aqueous suspension of the spores of *B. subtilis, var. niger,* generally known as *Bacillus globigii,* was aerosolized using commercially available nozzles. A satisfactory cloud was produced even though these nozzles were only about 5 per cent efficient in producing an initial cloud in the size range of 1 to 5 microns. In this test, 130 gallons of a suspension, having a count of 7.2×10^{9} organisms per ml, or a total of approximately 3.54×10^{15} spores, was aerosolized. The spraying operation was conducted from the rear deck of a small Naval vessel, cruising two miles off-shore and vertical to an on-shore breeze. Spraying continued along a two-mile course.

THIS operation was started at 5:00 p.m. and lasted for 29 minutes. There was a slight lapse condition, a moderate fog, and 100 per cent relative humidity. A network of sampling stations had been set up on shore. These were located at the homes of Government employees, in Government offices, buildings and reservations within the trial area. A rough attempt was made to characterize the vertical profile of the cloud by taking samples from outside the windows on the first, ninth, and fifteenth floors of a Government office building.

All samples were operated for a period of two hours except the one at station 31, which was operated for four hours. In this instance, there was a dosage of 562 during the first two hours and a total dosage of 1980 for the four-hour period, a four-fold increase. This suggests that the sampling period, particularly at the more distant locations, should have been increased.

SLIDE 5



As can be seen from this slide, an extensive area was covered by this aerosol. The maximum distance was station 43, located 23 miles from the source. As can be seen from these dosage isopleths, approximately 100 square miles was covered within the area sampled. It is quite likely that an even greater area was covered, particularly downwind. The dosages in the three levels of the vertical profile were:

First floor—3,440
Ninth floor—4,500
Fifteenth floor—562

This was not, of course, enough sampling to give a satisfactory description of the vertical diffusion of the aerosol.

A number of unique medical problems might be created when man is exposed to an infectious agent through the respiratory route rather than by the natural portal of entry. Some agents have been shown to be much more toxic or infectious to experimental animals when exposed to aerosols of optimum particle size than by the natural portal. Botulinal toxin, for example, is several thousand-fold more toxic by this route than when given per os. In some instances a different clinical disease picture may result from this route of exposure, making diagnosis difficult. In tularemia produced by aerosol exposure, one would not expect to find the classical ulcer of "rabbit fever" on a finger.

An enemy would obviously choose an agent that is believed to be highly infectious. Agents that are known to cause frequent infections among laboratory workers such as those causing Q fever, tularemia, brucellosis, glanders, coccidioidomycosis, etc., belong in this category.

Recently, Tigertt and Benenson (1956) reported the results of exposing human volunteers to aerosols of *Coxiella burnetii,* the causative agent of Q fever, during the course of studies of the effectiveness of vaccines. The respiratory dose was 10^{-9} grams of embryonated egg material containing the agent. In other words, a billion doses in a gram of material. Having given this figure, one must emphasize that there is no conceivable way of realizing this potential. This would imply that each individual would receive an exact dose without any wastage. It would mean that every cubic centimeter of infected air would be inhaled and then only in an amount required to infect. While these requirements cannot be met, nevertheless, the potency of such agents is enormous—so great in fact, that much wastage can be tolerated.

AN agent would likely be selected which would possess sufficient viability and virulence stability to meet realistic minimal logistic requirements. It is, obviously, a proper goal of research to improve on this property. In this connection it should be capable of being disseminated without excessive destruction. Moreover, it should not be so fastidious in its growth requirements as to make production on a militarily significant scale improbable.

An aggressor would use an agent against which there was a minimal naturally acquired or artificially induced immunity in a target population. A solid immunity is the one effective circumstance whereby attack by a specific agent can be neutralized. It must be remem-

(Continued on page 26)

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CHEMICAL CORPS SCHOOL SPECIALLY EQUIPPED FOR RADIOLOGICAL TRAINING AND RESEARCH

By **MAJOR JOHN B. BEACH**
Chief, Radiological Branch
Technical Division, Chemical Corps School
Fort McClellan, Alabama

ONE of the missions of the U.S. Army Chemical Corps School at Fort McClellan, Alabama, is to educate military and selected civilian personnel in the hazards of nuclear radiation, and to assist other service schools in radiological defense instruction.

It is the responsibility of the School's Radiological Branch to accomplish this mission. Because of its special qualifications and facilities, the Branch also performs certain research projects.

The two major courses in this field at the School are the Atomic Defense Course and the atomic portion of the Chemical Corps Advanced Course. Graduates of the former as well as those with sufficiently high grades in the latter are qualified in atomic defense, especially in the radiological aspects. They are also capable of assuming the duties of nuclear weapons employment officers.

Instruction in the defensive and safety aspects of nuclear radiation include such subjects as the protection afforded by shielding materials, the use of Radiac instruments, the planning and operation of radiological surveys, as well as monitoring and decontamination procedures. Much of this is done in the classroom; however, there is considerable practical work both in the laboratories and in the field.

Facilities for this purpose include a radiological defense laboratory, a radioisotopes laboratory, an improvised "hot cell," and a large radioactive area located at nearby Pelham Range.

The radiological defense laboratory is employed for training in the use of Radiac instruments, in determining radiation shielding properties of various materials, and in the handling of radioactive isotopes. Located in a separate building, this laboratory consists of two large rooms, each 50 by 50 feet, plus an instrument repair shop and storage rooms. Here students also calibrate various standard instruments.

The Radioisotope Laboratory, located in the main school building, contains equipment necessary for identification of unknown radioactive substances, for decontaminating instruments or other materials, and for developing and reading film badges. Included are scalers, Geiger-Mueller tubes mounted in lead cases, oscilloscopes, calibrated shielding material, as well as glassware, hoods, chemicals and cleaning apparatus.

The improvised "hot cell," built of concrete and lead blocks, has a thick leaded glass window for viewing and slave arms for handling radioactive materials remotely. It is presently being used to seal radioactive isotopes in brass capsules for easier handling. A permanent hot cell is planned for the future.

Major John B. Beach, author of the accompanying article, in addition to being a West Point graduate, has a Master's degree in Aeronautics and Guided Missiles from the University of Southern California, Los Angeles, and an M.S. degree in Physics awarded him by the U.S. Navy Postgraduate School, Monterey, Cal. Major Beach participated in four campaigns in the European Theater in World War II; also served in Korea and Japan. His decorations include the Silver Star with Oak Leaf Cluster; the Purple Heart, Combat Infantryman's Badge, the Bronze Star Medal, and the Army Commendation Ribbon with Metal Pendant. Born October 27, 1919 at Mare Island Navy Yard, Major Beach is the brother of Captain Edward L. Beach, USN, presently assigned to Office of Admiral Rickover, Bureau of Ships, Navy Department.

One of the most important of these facilities is a large radioactive field, used both for instruction and for research. Construction was started in 1954, when it became apparent that a need existed to simulate actual field conditions. Additions were made in 1955 and 1956.

Approximately ¾ by one mile in area, this field is traversed by about twenty miles of fire-break type trails which provide a road network similar to an area of much larger size. In addition, nine tank hulls are located in the area to act as landmarks. Landing sites for helicopters and small fixed-wing aircraft are also provided.

Point sources of Cobalt-60, of approximately 6 curies each, are buried in wells throughout the contaminated area. These sources are elevated when the field is in use, and at other times are lowered back into the wells, which are covered with lead caps locked into position to prevent tampering by unauthorized personnel.

Originally the field was of tear-drop design with a hollow center and contained 600 curies of Cobalt-60. Additions made in successive years raised the amount

of source material to the current total of 4418 curies. Both the area and level of radiation have been greatly increased—the original tear-drop design has now assumed a shape which is more or less rectangular.

In its original form, the field was adequate for instruction of ground survey procedures; the present form permits its use in aerial as well as ground surveys, and, in addition, permits the use of high-reading Radiac instruments. Conditions are now considered to be much more realistic. Consequently, considerably better instruction in radiological area surveying is possible.

Because of this specially constructed radioactive field, the U.S. Army Chemical Corps School has been given certain research projects to perform in addition to its primary instructional mission. One of these was a study of the feasibility of conducting radiological surveys from aircraft. Results indicated that rapid aerial surveys of large-area radiological contamination are feasible with standard or developmental Radiac instruments and standard Army aircraft. In addition, methods for performing aerial surveys were developed and tested.

Aerial surveys have been discussed a great deal as desirable alternatives to ground surveys, chiefly for two reasons: a large area can be covered in a short time, and survey personnel receive considerably lower doses of nuclear radiation than they would in a ground survey. However, aerial surveys are relatively inaccurate, since the readings obtained are strongly affected by a number of special factors—the ability of the pilot to maintain a constant altitude above the ground, for example. as well as the shielding effects of terrain features, the strong effect of radiation received from points far distant from the point of interest, and the directional shielding effects of the aircraft itself. Because of these factors, aerial surveys cannot be regarded as complete substitutes for ground surveys, but only as guides for general planning. Aerial surveys may be necessary or desirable under such conditions as the following: (1) When a large area must be surveyed in a relatively short time; (2) When an area must be surveyed which is not occupied by friendly troops; (3) When access to the survey area is slow or difficult; (4) When the survey area is too "hot" to be surveyed with reasonable safety from the ground; (5) When only a rough, general knowledge of the contamination is sufficient.

In most cases, portions of the area must be re-surveyed on the ground later if detailed plans and operations are to be carried out.

Aircraft used in tests were the H-13 and the H-21 helicopters and L-19 fixed-wing aircraft. Instruments included current standard, prospective standard and selected commercial types.

The procedures developed as a result of the studies were incorporated in the Department of the Army Training Circular 3-2, "Radiological Surveys," dated 25 April 1957.

Briefly, the procedures recommended are as follows: Surveys are performed by the pre-selected course (PSC) method, in which course legs are flown connecting selected ground check points; readings are taken at regular intervals along each leg. Recommended altitude for the survey is 500 feet or less, preferably under 200 feet. About 400 square miles can be surveyed in two hours with a light aircraft. In order to correct aerial readings to ground-level readings or values, an altitude correction factor must be applied to the aerial readings, and this factor must be determined each time a survey is made by landing at two or three places in the survey area to take ground readings.

Information was also obtained on the degree of error introduced by aircraft scattering and attenuation, and instrument response time. With the Radiac instrument inside the plane, it was found that attenuation of radiation by all aircraft tested was appreciable, and that this attenuation varied widely with the orientation of the craft toward the contamination. These errors were completely eliminated by the use of an instrument having its detecting element separated from the indicating dial and mounted or suspended beneath the aircraft. Because all Radiac instruments are unable to respond instantaneously, significant errors may be introduced if highspeed aircraft are used. For speeds of 100 knots or less these errors were found not to be excessive.

The tests also indicated that approximately one week's training in Radiac instruments and survey techniques, including considerable survey practice over a contaminated area, is necessary before inexperienced personnel can obtain accurate and reliable data.

Because of the great importance of nuclear radiation to battlefield tactics, it can reasonably be expected that these facilities of the Army Chemical Corps School will be utilized by other arms and services to a greater extent. In addition, new research projects will require a large area of contamination; until similar areas are constructed elsewhere, it can also be expected that these "hot grounds" will see action in such projects. Both the grounds and the laboratories may be made available to other military agencies upon request to the Chief Chemical Officer, Department of the Army, Washington 25, D.C.

Fort McClellan, Alabama—Ready for a radiological survey from a helicopter. The officer in charge talks over last minute details with the pilot while the men buckle themselves in. The officer has a special megaphone that can be heard over the deafening noise of the "copter."

COLORS OF NOTED WORLD WAR I GAS REGIMENT FORMALLY PRESENTED TO CML. CORPS SCHOOL

FORT McCLELLAN, Ala.—Graduation ceremonies for the Fourth Chemical Officer Basic Course, conducted recently at the U.S. Army Chemical Corps School, held dual importance as they not only climaxed 12 weeks training for new Chemical Corps officers, but also the unveiling of an historic chemical regiment's colors.

Col. Carl V. Burke, commandant of the School, introduced the guest speaker, Col. Maurice E. Barker, USA (Ret.), presently head of the University of Arkansas' Chemical Engineering Department. Colonel Barker, in keeping with the spirit of the unveiling of the First Chemical Regiment's colors, spoke on "The Highlights of the Chemical Corps Since Its Inception During World War I."

Colonel Barker, who was once commandant of the Chemical Corps School, told of the growth of the Corps from the time it consisted of only a few hundred men to today's highly complex organization.

Following the presentation of diplomas by Colonel Barker, Col. J. M. Palmer, commanding officer of the U.S. Army Chemical Corps Training Command, presided at ceremonies transferring custody of the First Chemical Regiment's Colors to the Chemical Corps School.

"The Chemical Warfare mission of the U.S. Army at the beginning of World War I was split: Medical, Ordnance, Signal, and the Corps of Engineers," stated Colonel Palmer in opening the ceremonies. "Chemical troops were combat troops and the major part of their work was the labor of installing gas projectors. Thus, it was logical in August 1917 when the War Department, by Presidential authority, directed the organization of one gas and flame regiment per Army, that the first unit should be an Engineer unit."

Colonel Palmer further stated that the recruiting and training of the Regiment, then called the 30th Engineer Regiment (Gas and Flame), was the responsibility of Capt. Earl J. Atkisson, who from August 1917, until Christmas of that year, raised volunteers and trained them at Camp American University, D.C.

In July 1918, the Chemical Warfare Service was made a part of the National Army and that same month the 30th Engineers was redesignated the First Gas Regiment, a name which it retained until the late 1920's when it was redesignated the First Chemical Regiment.

"The late Maj. Gen. E. F. Bullene, former Chief Chemical Officer, for whom we named the Chemical Corps Training Command Parade Field," Colonel Palmer said, "retained the Regiment's colors and they hung in the office of the commanding general of the Army Chemical Center, Md., for many years. But when the Chemical Corps School moved to Fort McClellan in August 1951, General Bullene was prevailed upon to permit us to send them along. He reluctantly agreed, insisting that they be preserved for Chemical troops of the future and that they be displayed where most Chemical Corps personnel could see them. I have felt this responsibility to be mine," Colonel Palmer continued, "since I was the officer so charged by the General. I now feel my obligation is fulfilled. I hereby pass the responsibility to the commandant of the Chemical Corps School."

Left to right: Col. Maurice E. Barker, USA (Ret.), guest speaker at graduation and Gas Regiment Color ceremony, Chemical Corps School; 2nd Lieut. Joseph R. Franke, member of the graduating class, and Col. John M. Palmer, Commanding Officer of the Chemical Corps Training Command.

In World War I, when the task of raising and training the new gas and flame regiment was given to Captain Atkisson, he immediately began a quest for men who were likely to have the required skill. Some were obtained from Engineer training camps and some from civilian life. An intensive recruiting campaign was inaugurated and so publicized that news of the formation of the new "Gas and Flame Regiment" reached every American. Some 350 newspapers gave their assistance.

An excerpt from a typical appeal that appeared in the *Boston Transcript* on 26 October 1917 follows:

WASHINGTON, D.C., Oct. 26—"Only keen, red-blooded men who are desirous of seeing active service are wanted for this regiment,"—so announces Maj. E. J. Atkisson, Corps of Engineers, upon whom has been placed the duty of organizing the "Hell Fire" Regiment with which to fight the Germans. The unit will be known officially as the "Gas and Flame Battalion" of the Thirtieth Engineers.

The first battalion of the regiment was formed quickly. They went through an intensive training program. The unit was ready for overseas service by Christmas 1917. It arrived in France on 10 January 1918. Meanwhile the Second Battalion was being trained at Fort Belvoir, Va. The First Battalion soon saw action after it arrived in France.

The regiment distinguished itself on many fronts. It fought on nearly every section of the Western Front from Ypres, Belgium to the Swiss border; from July to November it fought in the van of the three great American offensives and has credit for participation in five major battles. Before March 1919 it was reassembled, transported home and mustered out.

After World War I the regiment's name was changed to First Chemical Regiment and the Color, incorporating newly adopted insignia of the Chemical Warfare Service (see Front Cover picture) was designed. Before World War II the regiment was inactivated. Later a number of separate chemical mortar battalions were organized. These gained renown in World War II and in Korea. They in turn were inactivated and their weapon, the 4.2″ mortar, has been transferred to Infantry as a heavy mortar.

The present lineal descendant of the World War I regiment is the 62nd Smoke Generator Company, 100th Chemical Group (ComZ).

In addition to the First Chemical Regiment Color, the Color of the original 30th Engineers, made of red silk with embroidered Engineer insignia, was likewise turned over to the Chemical Corps School.

On the platform during the ceremonies, in addition to Colonel Palmer, was Col. Roland P. Fournier, USA (Ret.), both Colonel Palmer and Colonel Fournier having served in the First Chemical Regiment.

JET-AGE PARATROOP SMOKE SCREEN

Protective smoke screen, for delivery by jets. Streaks are produced by small agent carriers before reaching the ground.

The Army Chemical Corps has developed a new aircraft smoke tank which for the first time permits jet planes to lay down a smoke curtain for the concealment of paratroop jumps and other combat operations.

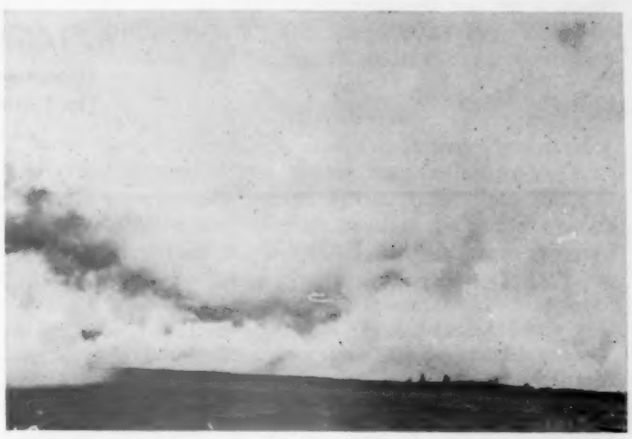
The new tank also produces a cloud free of gaps, for running a complete smoke curtain from 500 feet to the ground in about 25 seconds, as compared to from 5 to 25 minutes for previous types.

Developed at Army Chemical Center, Maryland, the tank is filled with small containers loaded with a standard smoke agent. After these are placed in the tank, more smoke agent is also added, filling in the "dead spaces" around the small containers.

During World War II, aerial smoke clouds effectively concealed both land and naval combat operations in many theaters. However, toward the end of the war, plane speeds had so increased that these "vertical" curtains were no longer feasible. As the agent was released, the rush of air past the openings broke the liquid into small droplets—causing the smoke to hang suspended in the air instead of falling to the ground as a protective screen.

When the new type tank opens, there are two effects at the same time; the agent in the "dead space" immediately forms an airborne cloud, and the small containers fall to the ground. Some of these containers release smoke during drop. The smoke used is known as FS, one of the standard agents.

A dense, vertical smoke curtain formed in only twenty-five (25) seconds.



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Few persons, we believe, had such exceptional opportunity as Dr. Senior, author of this article, to observe the early struggles of the principal Allies in World War I to produce mustard gas quickly and in quantities sufficient for retaliation. His narrative, the origin of which he explains in an accompanying note, accents both the human and dramatic aspects of this World War I technological problem.

The paper was first brought to the attention of THE JOURNAL by Colonel L. Wilson Greene, Chemical Warfare Laboratories, Army Chemical Center, as a matter of considerable historical interest. With the Chemical Corps commemorating its 40th anniversary this year, publication of the article at this time seems especially appropriate.

The second and concluding installment is scheduled for our November-December issue.

Dr. Senior is a native of Cincinnati. Now retired, he long served as Assistant and later as Associate Professor of Chemistry at the University of Chicago where he received his Ph.D. degree, as of 1917. He received his Bachelor and Master of Arts degrees at Harvard, as of 1911 and 1912, respectively.—Editor

THE MANUFACTURE OF MUSTARD GAS IN WORLD WAR I

By JAMES K. SENIOR*
Department of Chemistry
The University of Chicago
Chicago, Illinois

PART I

THE TECHNICAL PROBLEM OF THE ALLIES

On the 12th of July, 1917, the British troops in the neighborhood of Ypres took to their dugouts to protect themselves from an artillery bombardment. This attack did not seem to be anything out of the ordinary—merely another German "straf" of the kind to which they were thoroughly accustomed. Moreover, it was neither very lengthy nor particularly violent; and so, before long, they were out again, and once more engaged in the routine occupations of trench warfare. But within an hour or two strange symptoms began to appear among the men occupying the recently bombarded area. They developed violent conjunctivitis—so severe that their eyes closed up. Great areas of skin under their arms and between their legs turned fiery red and blistered. Many of them began to cough, and enough laryngitis to cause hoarseness was almost universal. Before the day was over, the number of casualties had passed from the hundreds into the thousands. In fact, there had been created a tactical situation to be compared only with the one which had followed the first cloud gas attack in the same salient of Ypres some two years before. At that time the whole British line was ruptured for a distance of three to five miles, and the casualties could never be accurately ascertained because of the large number of dead and wounded who fell into the hands of the enemy.

But in 1917 the British were better prepared. In spite of the fact that the bombardment of July 12 lacked all the features then supposed to be indicative of a gas attack—the gas cloud, the reek of chlorine or phosgene, the furious burst of many shell fired at once and without warning—in spite of the absence of all these signs, the officers in the field felt sure that they had been subjected to some new form of poison gas. After poking around in search of evidence for the existence of this new substance, they discovered here and there on the ground about the burst shells damp spots from which came a faint pungent odor something like horse-radish or mustard—and mustard gas was christened on the spot.

As the troops found out before long, the man who grubbed in this damp earth with his bare hand was doing well if the hand was out of bandages within two weeks. Anyone who sat down on such a spot was almost certain to be laid up for months. Forty or fifty dud shells were collected and observed to be marked with a yellow cross. They were rushed back to the Central Laboratory at Hesdin, and within eight days the new gas had been identified by Col. Harrison and Prof. Baker of the British Gas Service. It was dichlorodiethyl sulfide—a substance which had been known with certainty to organic chemists since 1886, and which had a somewhat more indefinite history running back another 26 years. The British gave it the code name of H.S., the French called it Yperite, the Americans later named it G-34 or M.O., and we of the Technical Division of the American Gas Service Headquarters, A.E.F., usually referred to it as Yellow Cross. But to the Tommy, the Poilu, and the Doughboy it remained "mustard" till the Armistice.

From the moment that mustard gas appeared, no one doubted its effectiveness. The early British casualties ran 5 per cent fatalities and 14 per cent severe cases—that is, cases removed from the line for three months or more. The British gas mask was found to protect the nose, mouth, and eyes very well; but nothing could prevent the skin burns. And in spite of numerous attempts to find a protection, till the end of the war nothing ever did.

*(Author's Note—1958.) This article is adapted from a paper which I wrote during the winter of 1921-1922, and read to the "Wednesday Club" of Cincinnati. That organization, of which I was then a member, was composed of business and professional men, most of whom had only a rudimentary knowledge of chemistry. After reading the paper, I filed the manuscript away, and did not see it again until some 35 years later, when it came to light during the clean-up which preceded a change in my residence.

The original text, save for certain very slight alterations and deletions, is here presented verbatim. At the time of writing, many of the events recounted were fresh and vivid in my memory, for I had served 17 months as first lieutenant in the Chemical Warfare Service, where I was assigned to the Technical Division of the American Gas Service Headquarters in France. The narrative is therefore, to the best of my knowledge and belief, strictly true. The descriptions of plants and processes as well as the opinions with regard to persons are here reproduced almost exactly as originally written.

There are, in the paper, a few scientific statements which, though believed in 1922 to be correct, would no longer be regarded as accurate. It is to be remembered that chemistry, both theoretical and technical, as well as pharmacology have, in the last 36 years, made considerable progress. At the present time, it would not be feasible, without extensive and laborious checking, to amend the few sentences in question.—J.K.S.

Within two weeks, the British called in Prof. Irvine of the University of St. Andrews, a well-known sugar chemist, to work out a method for preparing the compound on a large scale; but it was not until December 31st that Irvine reported. In order to understand the reasons for his delay, the problem which he faced must be explained in some detail; and this can best be done by recounting the ante bellum history of mustard gas.

In 1886, Victor Meyer set to work at Göttingen to solve some theoretical chemical questions the nature of which does not here concern us. What does interest us is the surprising nature of the results which he obtained along the road of his research. He began with ethylene chlorohydrin, a harmless oily liquid to which I shall have occasion to refer later on. He treated this compound with sodium sulfide and got thiodiglycol, another harmless oily liquid soluble in water. The reaction is:

$$2\ HOC_2H_4Cl + Na_2S = HOC_2H_4SC_2H_4OH + 2\ NaCl.$$

Then he treated his thiodiglycol with phosphorus trichloride according to the following reaction:

$$3\ HOC_2H_4SC_2H_4OH + 2\ PCl_3 =$$
$$3\ ClC_2H_4SC_2H_4Cl + 2\ P(OH)_3.$$

He got a heavy, slightly pungent liquid which was insoluble in water, and which first attracted his attention by nearly killing the assistant in charge of the preparation. This was highly astonishing. Nothing in the structure of the product would lead anyone to suspect it of harmful properties. (Note that it has no close connection with the common and comparatively innocuous class of compounds long known as mustard oils.) The materials from which it is made are either harmless or, at worst, mildly unpleasant. But, as will appear, all the nearest chemical relations of mustard gas are inoffensive. It is the only black sheep in its family, and, like so many other black sheep, it never played anything but an obscure role until the war broke out.

Meyer thought at first that he had to do with a personal idiosyncrasy on the part of his assistant, but he sent a sample of the new substance over to the pharmacology department of the local medical school, and before long he was undeceived. At the medical school, experiments on rabbits were undertaken. It was found that, when these animals were generally exposed to the fumes of the liquid, they first developed conjunctivitis and later died. If they were made to inhale the vapor in such a way that it never reached any part of their bodies except the respiratory tract, there was no conjunctivitis; but death resulted nevertheless. If the liquid was injected intravenously, the result was the same. And in all three instances, the cause of death was virulent pneumonia. Painting minute traces of the substance on the rabbits' skin produced severe burns like those Victor Meyer had noted on his assistant. Thus, within a few weeks of the discovery of mustard gas, its most important properties were pretty thoroughly investigated. To this day it remains, so far as I am aware (and I have the famous surgeon Crile for an authority), the only known drug, which, when injected intravenously, exerts a specific toxic effect on lung tissue. Meyer was convinced. He wrote as follows: "The intended work with this chloride was not continued—on account of the extremely poisonous qualities of the compound.—It is very striking that this apparently harmless substance which is only slightly volatile, is almost insoluble in water, and has a very slight odor as well as a perfectly neutral reaction, should exert a specific toxic effect. Its chemical constitution would never lead one to expect its aggressive properties."

Such were Victor Meyer's results. His method of preparation has since undergone no essential change. In 1912, a young chemist named Hans T. Clarke, a pupil of Emil Fischer in Berlin, had occasion to repeat Meyer's reactions.* He ended by introducing a slight improvement into the preparative process and giving himself some burns which later became historic. His improvement consisted in the substitution of hydrochloric acid for phosphorous trichloride in the second reaction shown. Thus modified, Victor Meyer's method still stands as the best known way of preparing mustard gas on a small scale in the laboratory; and in point of fact, it is the method by which the Germans made every ounce they ever used.

Right here it should be stated that there are stories afloat of men who, eighteen months before the first German mustard gas attack, synthesized small samples of the substance and offered them to both the French and English governments—by whom they were rejected as valueless. In Bertrand's laboratory at the Pasteur Institute, I met an assistant who claimed to be one of these men. But I never could get his tale officially affirmed or denied; so I have my doubts.

In view of all these facts, you will naturally wonder why Irvine took so long to report. He was acquainted from the first with the work of Meyer and Fischer, and he found no difficulty in carrying out Meyer's two reactions on both a small and a large scale. Sodium sulfide and hydrochloric acid are cheap and common enough. The trouble was to make the ethylene chlorohydrin, the liquid with which Meyer had started. Indeed, about two-thirds of Irvine's report deals with his attempts to prepare this substance. For years the Germans had made it in their dye factories; and it is interesting to note that (as we now know) their large-scale method of preparation resembles very closely the one worked out by Irvine.

Irvine recommended that ethylene chlorohydrin be made by the action of hypochlorous acid on ethylene:

$$H_2O + Cl_2 = HOCl + HCl$$
$$HOCl + H_2C{=}CH_2 = HOCH_2CH_2Cl.$$

His scheme was to pump chlorine into a closed vessel half-full of water and then to pump in ethylene. The ethylene combined with the hypochlorous acid until all of that acid was used up. More chlorine was then pumped in, then more ethylene, and so on until the ethylene chlorohydrin in the water became so concentrated that the reaction stopped. Finally the chlorohydrin was separated by distillation.

I shall not forget how I felt on first reading Irvine's report. When I saw how slowly the reaction went, how carefully each gas had to be removed from the reactor before the other gas was introduced, how cumbersome and expensive was the apparatus for shaking the water solution, and how little success Irvine had met with in his search for a catalyzer to speed up the reaction, my heart sank. Nevertheless the English did seriously consider putting Irvine's method into use on a large scale; and with this end in view they laid out with a British

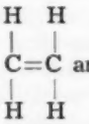
*Dr. Clarke later became professor, College of Physicians and Surgeons, Columbia University. He described his experience with mustard gas in a letter to Dr. R. Macy, Chief, Chemical Division, Army Chemical Center, dated December 23, 1947, which was published in the April 1948 number of the Journal (then entitled Chemical Corps Journal). In his letter he stated he suffered burns on the leg which resulted from breakage of a flask of mustard causing his hospitalization for nearly two months. He said that he could not avoid the suspicion that the Germans' resort to the use of mustard gas was ascribable to a report of his injuries which was made to the German Chemical Society.—ed.

chemical manufacturer the plans for a factory. Events to which I shall soon refer ended these schemes.

In the meantime, things had not been at a standstill in the United States. The research work of the gas service was then in the hands of the Bureau of Mines. They called in Moses Gomberg of the University of Michigan, perhaps the ablest organic chemist in the country, and gave him the specific job of working up the Victor Meyer method. But Gomberg's first report was not in till March 1918, and his final one not till June of the same year. On the whole, his work was more thorough and better planned than Irvine's; but he ended up with essentially the same methods and results; only his were a trifle less discouraging. However, the events which rendered Irvine's work abortive made Gomberg's efforts also futile. But to understand these events a very different type of reaction must be considered.

The elements sulfur and chlorine combine with one another in different proportions to form two distinct compounds. The first is sulfur dichloride, Cl-S-Cl, and the second is sulfur monochloride concerning which there is some doubt. Two structural formulae Cl-S-S-Cl and Cl–S–Cl have been assigned to it by different observers.

It will soon be seen how much this obscure point in chemical theory had to do with the production of mustard gas. Both of the sulfur chlorides are heavy liquids which decompose on contact with water. Both can be easily prepared by the direct action of chlorine on sulfur. The monochloride, in fact, is a common commercial chemical used in large quantities by the rubber industry.

It was seen at once that in ethylene  and sulfur dichloride Cl–S–Cl there were all the atoms needed to make mustard gas. The problem was to induce these substances to combine with one another in the proper proportions. If one sulfur dichloride molecule could be made to combine properly with two ethylene molecules, mustard gas would be formed by a single reaction from two comparatively cheap and accessible substances. The hoped-for reaction could be written as follows:

$$2\ H_2C{=}CH_2 + SCl_2 = ClC_2H_4SC_2H_4Cl$$

It was tantalizingly simple on paper, and as early as November 1917, during my first visit to Washington, I heard of the possibilities of the method just described. This was my first introduction to the reaction which later became so famous. But many people had already thought of it. They immediately searched the literature to find out whether anyone had ever tried to combine ethylene with either of the chlorides of sulfur. And they discovered that it had been done.

Way back about 1860, Guthrie in England, Despretz in France, and Niemann in Germany, all working at nearly the same time, had tried out the reaction. At that period, organic chemistry was in its infancy. Structural formulae were almost unknown, and even the system of notation was chaotic. The methods of analysis were so defective that the published figures mean very little. In fact it is hard to translate the articles of that day into modern terminology. Guthrie, Despretz, and Niemann all treated various mixtures of sulfur monochloride and sulfur diochloride with ethylene, and obtained a number of different substances which they took to be pure compounds. Among these, both Guthrie and Niemann noted one which had a decidedly corrosive action on the skin. It is highly probable that both of them had samples of impure mustard gas in their hands.

This literature was all well known. Irvine mentioned it in his December report. He stated that he had tried a few rough experiments along the line indicated, but had given them up because he could not get the reaction to work. This was indeed unfortunate for, had he persisted and succeeded, the mustard gas program might have been advanced by several months. In the experiment station at the American University, this method of attacking the problem had been turned over to a young lieutenant named James Bryant Conant.

But the solution was finally reached by another British scientist. When I got to Paris early in March, 1918, I found one bright spot in a very discouraging landscape. In the laboratory at Puteaux, there was a report by William Pope,* a well known professor of chemistry in Cambridge, England. This had been sent to us by the English gas service, and was dated February 23, 1918. It stated that the author had succeeded in making mustard gas by reacting on ethylene with sulfur monochloride at 70° Centigrade. He had kept his reaction vessel in constant agitation, and had used adsorbent charcoal to speed up the process.

Pope had begun work in November and had reported his first success in January 1918. The news was cabled to Washington, where it arrived just in time to prevent Conant from announcing the same discovery. He had made mustard gas essentially as Pope had made it, shortly after Pope succeeded, and just a few days before the news of Pope's success reached America. In Puteaux, despite the fact that, at the time, almost every facility for preparative work was lacking, we managed to repeat Pope's work on a test tube scale, just to assure ourselves of its correctness.

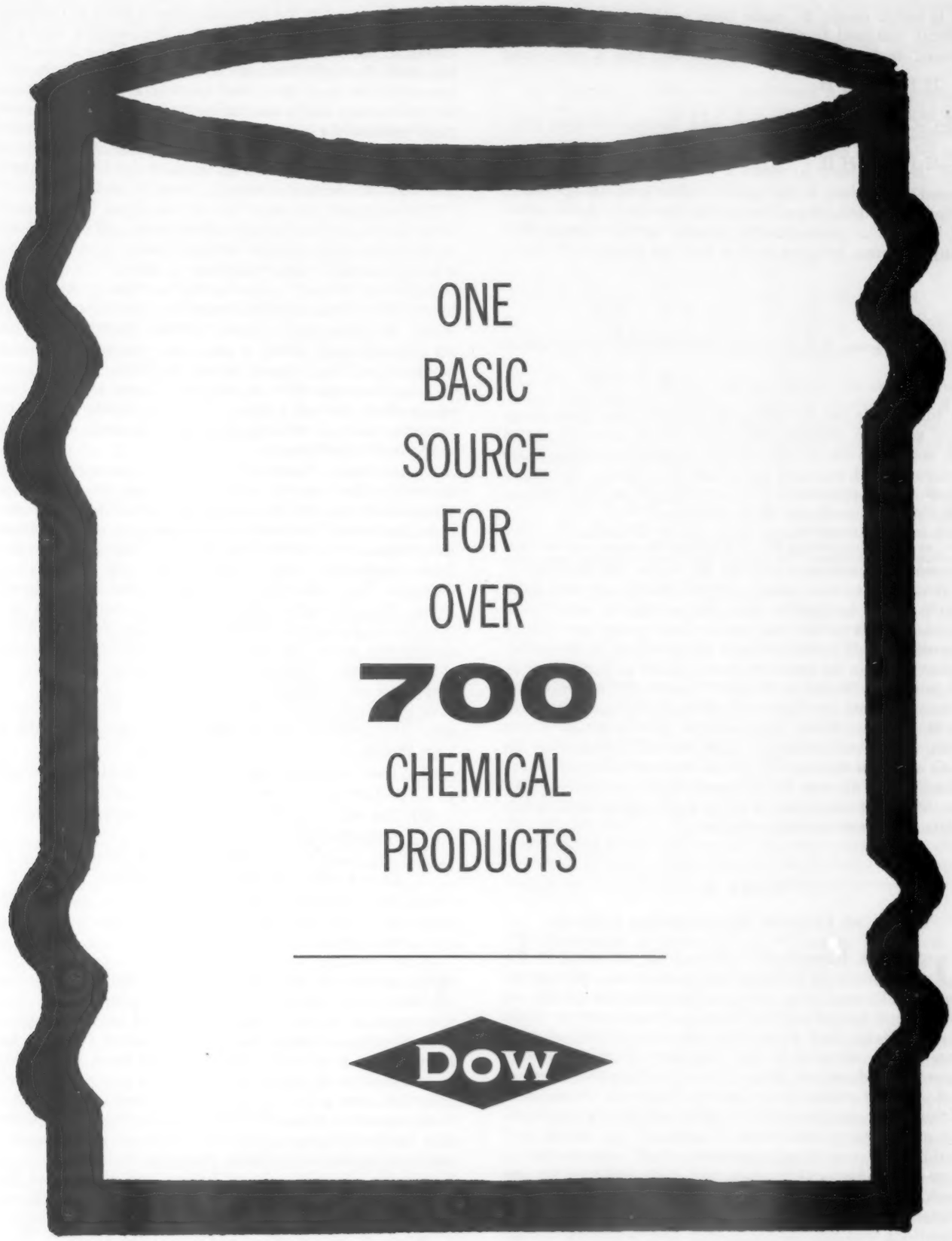
From March until July, 1918, my own work was largely with mustard gas of German origin, and I got a fairly complete knowledge of that substance—absorbing a considerable amount of the information through my skin. During this period, many investigators entered the field, and what was originally known as the Pope process split up into half a dozen variations, as different men tried different methods of dodging the obstacles involved. Since it would be very confusing to try to trace back each detail to its inventor, I shall discuss only the results obtained.

As already stated, Pope obtained his first mustard gas not from sulfur dichloride which might be expected to work, but from sulfur monochloride which, on *a priori* grounds, ought to give something quite different. We know now that the dichloride really does form the mustard gas very promptly, but unfortunately also destroys it with equal promptness. The destruction is due to the fact that sulfur dichloride has a strong tendency to give off chlorine, which replaces one or more of the hydrogen atoms in the mustard gas, so that, instead of forming a compound with two atoms of chlorine in the molecule, there is produced one with three or four atoms of chlorine. It is of a piece with the eccentric behavior of mustard gas that, although introducing two atoms of chlorine into the harmless diethyl sulfide molecule renders that molecule violently toxic, introducing a third or a fourth atom of chlorine destroys nearly all of the offensive properties. This is one horn of the dilemma faced by the manufacturer.

Sulfur monochloride had been regarded from the beginning as a sort of second bet, in spite of the fact that

*Sir William Pope, knighted in 1919 for his contributions to science including his work on mustard gas.—*ed.*

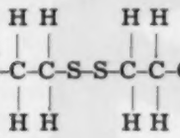
(Continued on page 16)



Industrial Chemicals • Agricultural Chemicals • Plastics • Magnesium

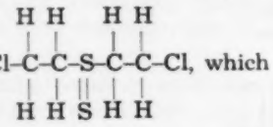
THE DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN

it is much easier to make than is the dichloride. Most people assigned to it the formula, Cl–S–S–Cl, and they feared that it would form with ethylene a compound



pared and shown to be, like all other substances closely related to mustard gas, relatively harmless. As a matter of fact, sulfur monochloride, insofar as its reaction with ethylene goes, behaves as if it had the formula Cl-S-Cl.

With ethylene, it first forms



in turn drops off the extra sulfur atom and gives mustard gas. But unfortunately the sulfur, when it drops off, separates out of the reaction mixture as a fine paste saturated with mustard gas which clogs all the valves and pipes of the apparatus and defies attempts at filtration. This is the second horn of the dilemma.

(Author's Note 1958: During World War II the reaction by which the "extra" sulfur atom is eliminated from the reaction product was thoroughly investigated. The process was found to be far more complicated than was suspected in 1919. Cf. Science *106*, 355 (1947).)

It is easy to talk calmly of difficulties and dilemmas, but it would be hard to give you an idea of what these words meant while the work was going on. Sulfur deposition was the nightmare of the working force, because to clean an apparatus was about as dangerous as to jump off Brooklyn Bridge. I can well remember an evening during my visit to the French mustard-gas plant at Roussillon. Word was brought to the group I was with, as we sat at supper, that the concentrator at the base of one of the big reactor columns had clogged. There was a blank silence, for it meant that the next evening would see at least one of us in the hospital with a fair chance of never coming out alive.

PART II

Visits to French Mustard-Gas Plants

On July 8, I received word to drop my work at the laboratory in Puteaux and to start on a tour of inspection through the various mustard-gas plants in France and England. After the trip, I was to return to the United States and place my information and experience at the disposal of the Chemical Warfare Service arsenal at Edgewood. While I was handling the chemical end of the investigation, Captain Frederick Pope,* also of the American gas service, was to manage the engineering end. Against this order I protested as firmly as I could, for I was totally ignorant of all commercial or large-scale chemical practice and quite unfitted for the work. Moreover, there were at hand men able and anxious to do the job. But all I got in answer to my objections was the statement that I would carry out the order in any case, and that if I kicked any more I would not be allowed to return to France after the work was finished. So I shut up.

On the 10th of July, Captain Pope and I got to Lyons where we were met by the head engineer of the Société Chimique des Usines du Rhone. The destruction by the Germans of the great St. Gobain plant at Chaulnes had left the Usines du Rhone the largest synthetic chemical manufacturing firm in France. Their main plant lay at St. Fons, just outside of Lyons; but since the outbreak of the war, they had erected a large new plant some 30 miles down the Rhone at Roussillon. The company possessed a large capital and very close government connections. Since it was engaged almost entirely in war work, it was granted all sorts of extra privileges in the way of obtaining supplies, raw materials, etc.

The mustard gas plant lay at Roussillon, where there was also located the factory which produced the majority of the enormous amount of saccharine used in France during the war; there was also a phenol works with a capacity of 150 tons a day—so far as I know, the largest single phenol plant in the world at that time. To Roussillon we accordingly drove, and the fact that we had an automobile in which to make the trip was the strongest proof of the company's pull in Paris, for in France all use of automobiles by private persons had long been suppressed. Before evening I was at work getting my introduction to French methods of large-scale production under war conditions.

On the basis of laboratory experiments with both the monochloride and dichloride of sulfur, the Usines du Rhone had reached the conclusion that, when the monochloride is used to produce mustard gas, sulfur deposition cannot be avoided. This is not so. But starting with a false assumption, the company came to a very wise decision. They abandoned the use of the monochloride. They did not make the error of trying to get that murderous sludge out of their apparatus. To avoid introducing too much chlorine into the product, they diluted the dichloride, instead of using it pure. The solvent employed as a diluent was carbon tetrachloride, which they got from the Dow Chemical Co. of Midland, Michigan. The process was a continuous one consisting of four stages:

(1) The formation of the sulfur dichloride by the action of chlorine on sulfur.

(2) The dilution of the sulfur dichloride with carbon tetrachloride.

(3) The reaction of ethylene with this solution to form a dilute solution of mustard gas.

(4) The distillation of the solution to separate the mustard gas from the solvent, which was used over again.

To accomplish this whole process the company had contrived the most astonishing apparatus I have ever seen or expect to see as long as I live. It consisted of a number of large towers (the tallest fully 60 feet high) all built entirely of lead. At the time, France had been swept nearly clean of iron. Lead pipe cost less per foot than iron pipe, a fact which in itself was enough to turn American ideas of plant construction upside down. But the French, even in peace times, are accustomed to use lead much more freely than we do. In France, all the water pipes in private houses are of lead, so that there a plumber is just what his name implies. Consequently, in France, the art of lead working has reached a degree of perfection unknown in this country. Those tremendous towers filled with a most complicated system of cooling coils and interlaced by a bewildering network of pipes and condensers were the most gorgeous piece of lead burning I have ever come across. I doubt if they could have been duplicated in this country at any price.

Below each of the four reactors stood a worm concentrator of solid silver. I never did find out just how much silver there was in each one, but, at a guess, I

*American C.W.S. officer. Not to be confused with British chemist, Sir William Pope, previously mentioned in this article.—ed.

should say there could hardly have been less than a ton. Of course this silver was not destroyed in the process, but it must have immobilized a very fair capital.

To run this curious affair required about six men per reactor; and during the time they were on duty they got very little chance for rest. The flow of the various liquids and gases through the apparatus was measured by meters, dials, and gauges. Each one of these had to be read every 15 minutes, and the control sheet called for 32 such columns of figures. Moreover, since the indicators were located at all sorts of different heights up and down the towers, they were only to be reached by climbing about on ladders and staging rigged up for that purpose. Two men were employed on this job. Below at a desk stood a clerk taking down the figures called out to him by the two human monkeys constantly scrambling about on the equipment above his head.

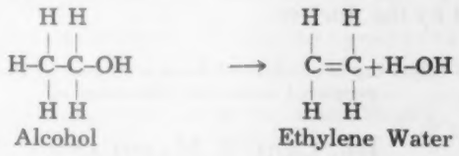
As stated, the process was a continuous one, and the designers appear to have believed that, once started, the apparatus would run smoothly and without alteration as long as necessary. At any rate, I do not recollect that they had provided for a single manhole, union, pet cock or bypass on the whole complicated affair. When anything went wrong (and something was constantly going wrong) it was necessary to take a cold chisel and break into the lead work. The concrete floor of the building had no drains. Consequently, whenever there was a spill, the workmen had to get a hose and squirt the drippings out through the door into the sewer. Needless to tell, casualties were frequent.

Right here I want to say a word in praise of the working forces in all the mustard gas plants I ever was in. They suffered from a kind of poisoning which comes from prolonged exposure to very low concentrations of the gas, and which is seldom seen in the field.* It might be called a chronic form of gas poisoning in contrast to the acute forms usually met with on the line. It does not cause many deaths, but there is some doubt whether any more efficient method of making a man wish himself dead has ever been invented.

THE personnel of a mustard gas plant is 90 per cent voiceless. About 50 per cent cough continuously. More serious affections of the respiratory tract are uncommon. Conjunctivitis is almost universal, and of a form which may seem common to physicians, but which to the layman is quite striking. The white of the eye where it is exposed to the air becomes violently inflamed. The sclera, where protected by the eyelids, is almost untouched, so that, if the lids are drawn back, the eyes present a curious banded barber-pole appearance which we used to call "mustard gas eye." Only in case of accident do men get enough of the liquid on them to cause blisters. But, by long exposure to the small amounts of vapor constantly present in the air of the work rooms, the initial resistance of the skin is finally broken down. It turns bright red and begins to peel off layer after layer. The chief result is that the itch makes sleep nearly impossible and the laborers become very much run down.

Under these trying conditions, the workers (both men and women) maintained a cheerfulness and steadiness highly to their credit. To stand near the gate in Roussillon and watch the day shift at the mustard gas plant file by was enough to touch the hardest heart. Those voiceless, red-eyed, coughing, scrofulous skeletons (almost all the men had been wounded and released from active duty) stuck to their jobs month after month with the spirit of a crack battalion. And yet they knew that, as long as the war lasted, the only possible change in their condition would be one for the worse.

All this time I have not mentioned a very important problem which arose in every mustard gas plant—the production of ethylene. There are a number of different raw materials from which ethylene can be made, but every mustard gas plant I know of used alcohol. The scheme was to vaporize the alcohol and pass it over some form of heated oxide which split the alcohol into water and ethylene



This reaction is a ticklish one because, if the temperature is too low, ether is formed instead of ethylene; and if it is too high, the ethylene chars and burns out the furnace. Moreover, a variety of impurities may poison the oxide and render it inactive.

The Usines du Rhone used alumnium oxide in an electrically heated furnace. I speak of this subject because the furnace room gave us more amusement than any other part of the plant. Those furnaces were as temperamental as a set of prima donnas. Sometimes they worked, sometimes they didn't; and no man could tell why. I doubt if they ever would have run at all, had it not been that the furnace room foreman was just about as temperamental as they were. He was an old lieutenant of infantry—a gusty sort of a chap with a tremendous brown beard that swept his chest. He treated the furnaces and the girls who ran them just about alike —that is paternally. He managed them all not so much by rule of thumb as by a sort of instinct which he could no more explain than I can. Word would come from the laboratory that furnace No. 5 was working badly. He would gently lay his ear for a moment against the asbestos covering of the reactor, thumb a couple of the valves, and finally tap one of the electrodes with a little hammer. Within a half a minute the furnace would start up again as obediently as a well-trained horse.

THE process of manufacture in use at Roussillon at the time I was there was still undergoing rapid development. Attempts were made to replace the reaction towers by agitators, thus bringing the procedure much more in line with English and American practice. After a fashion the plant worked. When all was going well, the four units could turn out close to 15 tons a day of so-called mustard gas. A second building of the same capacity as the first was being erected; but, in view of the antediluvian methods of concrete construction employed by the French, I doubt if it was finished before the Armistice. During my visit, the French government sent down a group of chemists and engineers to learn to operate the works, because one on the same lines was being built in the arsenal at Angoulême. The Italians, with a similar end in view, also sent up a number of officers. But, so far as I know, neither of these plants was ever completed.

The cost of manufacture was terrific. Owing to grossly insufficient pumping capacity, the condensers operated so inefficiently that between one-third and one-half of the good American alcohol and carbon tetrachloride

(Continued on page 29)

*In World War II producton methods were relatively safe.—ed.

AMERICAN CHEMICAL SOCIETY COMMITTEE ADVISORY TO THE CHEMICAL CORPS

Gathering of eminent scientists who are now or were previously connected with the Chemical Corps program at Army Chemical Center May 19-20 marks the 40th Anniversary of the establishment of the Corps with a conference reviewing the Corps' history with special reference to the support rendered by the Society.

The following is condensed from a Report of the Meeting prepared under the direction of

DR. CARL B. MARQUAND

Executive Director of the
U. S. Army Chemical Corps Advisory Council
and the
American Chemical Society Committee
Advisory to the Chemical Corps
Assisted by: Mrs. Pyree Vogt and Mrs. Marion P. Barras of the Advisory Council Staff

THE Committee (American Chemical Society) Advisory to the U.S. Army Chemical Corps held its annual meeting at Edgewood, Maryland, on May 19 and 20.

The meeting marked the 40th anniversary of the Corps (formerly Chemical Warfare Service), and the 38th anniversary of the committee.

More than 50 members and representatives from industry, colleges and universities participated in the program, which included research and development phases of the Chemical Corps, as well as medical, public health, and civil-defense matters relating to chemical and biological warfare.

Brig. Gen. Harold Walmsley, commanding officer at Army Chemical Center, Maryland, welcomed the large group to the installation.

The mission of the Committee is to advise the Chief Chemical Officer regarding policies and procedures employed by the Chemical Corps' research and development program. It has four subcommittees (Public Relations, Educational, Industrial Relations, and Research).

Special emphasis was given at the meeting to the study of ways and means of increasing the public-relations status of the Corps.

At a luncheon meeting on the 20th, Mr. J. Lewis Powell, Office of the Assistant Secretary of Defense, Supply and Logistics, made an address on "The Collapse of Time." He based his talk on a time curve starting with the era of Nero and projected it into the 1970's, and showed how time and space have been telescoped in a little more than a decade. Any extrapolation of the Powell curve can only accentuate the fact that the decades ahead will witness fantastic new breakthroughs in most, if not all, of the physical sciences.

After the welcoming remarks by Brig. Gen. Walmsley on the 19th, the years 1917-1920 were discussed.

The panelists covering this period (1917-1920) were Dr. Wyndham D. Miles, Dr. Charles C. Price, Dr. Harold C. Weber, Dr. E. Emmet Reid, Dr. Harold S. King and Mr. Earl P. Stevenson.

Dr. Miles is chairman of the Division of History of the American Chemical Society, and Historian at the Historical Office, Army Chemical Center. He compared the beginning of the Chemical Warfare Service to a tree with many roots. He recalled that the Bureau of Mines began chemical-warfare research shortly before the United States entered World War I. The Medical Department took over the gas-mask program in the summer of 1917. The Ordnance Department began to erect gas plants in late 1917, and laid out a proving ground at Lakehurst, New Jersey. The AEF established its own laboratory and proving ground early in 1918. The Signal Corps provided gas alarms, and the Engineers gave its 30th Regiment as combat troops.

These branches were brought together in June 1918—into the Chemical Warfare Service. This new Service had 20,000 men by November 1918, but after the Armistice, the Service dwindled to a "mere handful." In 1919, Congress extended the life of the Service for another year. In 1920 Congress made it a permanent branch of the Army.

The next panelist, Dr. Charles C. Price, is a Blanchard Professor of Chemistry, and Department Director, University of Pennsylvania. He was formerly a member of the Educational Subcommittee, and Chairman of the Committee (ACS) Advisory to the Chemical Corps.

Dr. Price discussed the association between the American Chemical Society and the Chemical Warfare Service during 1917-1920.

In February 1917, President Julius Stieglitz of the Society wrote to President Wilson, offering the services of the 8,000 members of the Society. An editorial in the March 1917 issue of "Industrial and Engineering Chemistry" read in part as follows:

"In this grave period of our country's history, the chemists of America pledge to President Wilson their undivided

(Continued on page 22)

DR. CARL BERTRAM MARQUAND has been engaged in scientific work of the Army Chemical Corps since 1940 serving first with the Vesicant Section, Medical Division, later as head of the Gas Chamber Section at Army Chemical Center. He was a member of the Chemical Corps Project Coordination Staff established in 1945, and has been executive director of the U.S. Army Chemical Corps Advisory Council and the American Chemical Society Committee Advisory to the Chemical Corps since 1947. He is also executive director of the Society of American Bacteriologists Committee Advisory to the Chemical Corps.

Dr. Marquand has A.B., M.Sc., and Ph.D. degrees from Ohio State University. He has designed various items of scientific equipment for toxicity studies and is the author of a number of papers pertaining to toxicity of chemical agents.

In addition to the ACS he is a member of the National Education Association, Sigma Xi, and a number of other professional and social organizations.

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Cylinders

Chromium Chemicals
Alumina Hydrate
Sodium Bichromate
Crystal, Granular, Liquid
Sodium Chromate
Potassium Bichromate
Chrome Salt Cake
Chromic Acid
Tanolins* (Tanning Salts)
Synthetic Tans
Tanning Oils and Fat Liquors
CPA 1800* (Chrome-Plating Additives)

Sodium Silicates
Silicate of Soda, Liquid
All Grades
Water White, 42°
Silicate of Soda, Concrete Special
Versilad* and Versilate* (Adhesives)
Silicate of Soda, Glass
Detergent Silicates
Moroc* Foundry Sand Binder
Sodium Metasilicate, Anhydrous
Sodium Metasilicate, Pentahydrate

Chlorinated Products
Muriatic Acid (Commercial and Water White)
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Anhydrous Hydrogen Chloride
Carbon Tetrachloride
Tank Cars and Drums
Chlorowax* 70 and 70S (Resinous Chlorinated Paraffins)
Chlorowax* 40, 50 and LV (Liquid Chlorinated Paraffins)
Perchlorethylene
Methyl Chloride
Methylene Chloride
Chloroform
Hexachlorobenzene
Hexachlorobutadiene-1, 3
Fire Extinguisher Liquid
Chloral
2, 4 Dichlorophenol
2, 4, 5 Trichlorophenol
2, 4, 6 Trichlorophenol
Benzene Sulfonyl Chloride
Parachlorobenzene Sulfonyl Chloride
Parachlorobenzene Sulfonamide
Phenoxyacetic Acid
2, 4, 6-Trichloroanisole
Ethylene Dichloride

Calcium Carbonates
Precipitated Calcium Carbonate Pigments for Paint, Rubber, Plastics, Glass and Printing Ink:

Suspenso*	Surfex MM*
Millical*	Multifex MM*
Non-Fer-Al*	Super-Multifex*
Carbium	Kalite*
Surfex*	U.S.P. Dense

Cement and Coke Products
Portland Cement
Masonry Cement
High Early Strength Cement
Waterproof Gray Cement
Foundry and Industrial Coke
Benzol

Toluol	Xylol
Crude Ammonia	Tar

Detergents and Chemicals for the Laundry Industry
Laundry Soda
Diamond Soda Crystals
Laundry Sours
Laundry Liquid Blue
Hi-Ratio Silicate*
Hydrobreak*
Hydrolate*

Paralate*	Paralate*S
Alkalate*	Metalate

O & W Compound*
Ortholate
Sodium Metasilicate, Anhydrous
Sodium Metasilicate, Pentahydrate
Sodium Orthosilicate
Sodium Supersilicate
Suspensoil
58% Soda Ash
Washroom Control Kit

Industrial Cleansers and Chemicals for the Food, Dairy and Beverage Industries
Aquid* (Liquid Detergent)
Bomber* (Dairy and Creamery Detergent)
Cirkal* (for Mechanical and Circulation Cleaning)
Citrospeed*
Cleaner and Cleanser
Diamid* (Liquid Acid Cleaner)
Diamond Soda Crystals
Dreadnaught* Cleaner
Economy Cleaner
Special Alkalies (Causticized Ash, all strengths)
Special Alkalate
Hardnox Alkali* (Bottle Washing)
Hi-Speed* Cleaner
Hi-Test Alkali* (Bottle Washing)
Horizo* (Chlorinated Phosphate-Type Sanitizer)
HW Soaker Alkali* (Bottle Washing)
Diamond Detergent
Hydrolate*
Hydrobreak*
All-Purpose "W"* Cleaner
Compounds for Specific Uses
Modified Soda
BB Soaker Alkali (Bottle Washing)
Clipper Cleaner*
CH-100* and CH-101 (Bottle Washing)
Powdered Acid Cleaner
Pre-Mix Tank Washing Compound
Samson* Can Washing Compound

Sequet*	Sesquilate*
Neutral 50* Cleaner	
Nu-Met*	Nutralac

Agricultural Chemicals
DDT (Technical and Concentrates)
BHC (Technical and Concentrates)
2, 4-D (Acid, Salts, Esters, and Formulations)
2, 4, 5-T (Acid, Salts, Esters, and Formulations)
Lindane (100% and Concentrates)
Miticide K-101 (Technical)
Hexachlorobenzene (Technical and Formulations)
Grain Fumigants
Dacfia
Diamond "80-20"*
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Plastic Resins and Compounds
Polyvinyl Chloride Resins
Diamond PVC-50 (High Molecular Weight—U.L. Approved)
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Compounds
Diamond Compound R4 (for Rigid PVC Applications)
Compounds for Specific Applications

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**Reg. U. S. Pat. Off.*

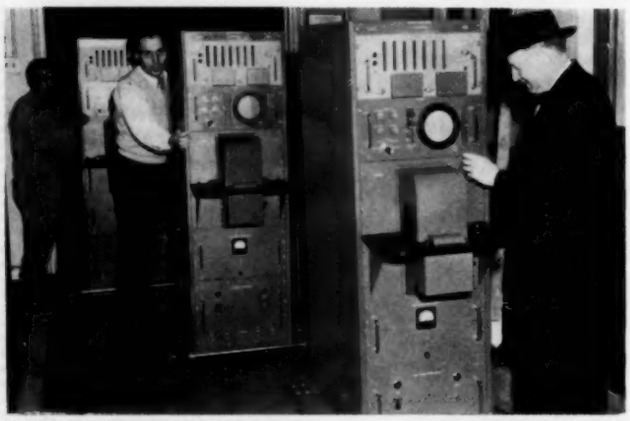
Diamond Chemicals

FAR & WIDE WITH THE CHEMICAL CORPS 1958

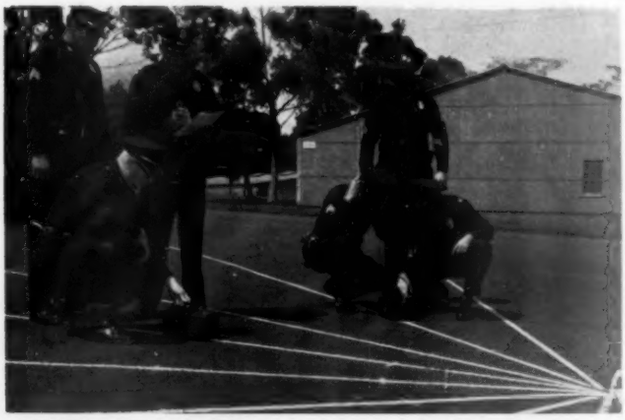
ARMY CHEMICAL CENTER, Md.—GAS! Soldiers in combat exercises demonstrate E-13 protective mask which eliminates outside canister.

FORT BRAGG, N. C.—Students at 5-day CBR School, equipped with impregnated protective clothing, get practical exercise in use of bleach to decontaminate a gas-contaminated area.

FORT STEWART, Ga.—Men in Co. A, 1st Battle Group, 30th Infantry, 3rd Division, using rocket launcher against "enemy" during simulated CBR attack in combined tank-infantry team exercises.



FORT DETRICK, Md.—Mr. Nelson E. Alexander (right), project officer for development of automatic colony counter, inspects three of the machines on their delivery to Detrick. They put some phases of bacteriological research on automation basis.

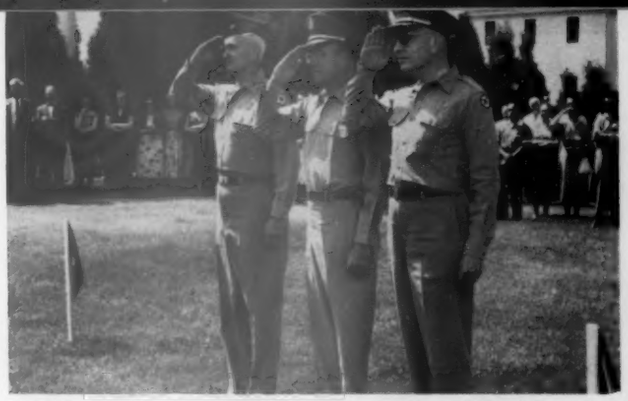


SCHOFIELD BARRACKS, Territory of Hawaii. Oahu police checking radiac instruments during 2-day radiological defense course provided for them by Chemical Section of 25th Infantry Division.

ROCKY MOUNTAIN ARSENAL, Denver, Colo.—The 40th birthday of the Chemical Corps was celebrated with a formal review of troops, June 30, by Brig. General Charles S. Shadle, USA (Ret.), former commander of the Arsenal. The Troop Commander (at left in picture) was General Shadle's son, Major Charles M. Shadle. Others in reviewing party were Lt. Colonel B. R. Bierer, Commanding Officer, and Lt. Colonel Norman H. Crandell, Executive Officer of the Arsenal.

PHILADELPHIA, Pennsylvania—BW Laboratories, Ft. Detrick, Md., display at National Tuberculosis Association Convention, May 18-23, the Henderson Apparatus, a means of safely creating infectious aerosols in laboratories for test purposes. Examining the exhibit are (left to right) Dr. C. W. Twinam, State Sanatorium, North Wilmington, Mass.; Dr. R. J. Janssen, Ft. Detrick, Md.; Dr. C. Northrop, Tuberculosis Control Officer, State of Washington; and Dr. W. F. Kirchheimer, Deputy Safety Director, Ft. Detrick.

WASHINGTON, D. C.—Captain Frances Berg, WAC officer, before leaving Public Relations post in Chief's Office, Washington, D.C., for WAC recruiting duty in Louisville, Ky., receives Army Commendation Ribbon presented by General Creasy, Chief Chemical Officer.



ROCKY MOUNTAIN ARSENAL, Denver, Colo.—Colonel Ronald L. Martin, Arsenal Commander, (left), at his final review of troops prior to his departure for duty with Research and Development Division, OC ChemC, Washington, D.C.; (center) Colonel W. A. Johnson, who succeeded Colonel Martin, and (right) Colonel B. R. Bierer, Deputy Commander.

ARMY CHEMICAL CENTER, Md.—Post Commander Brig. General Harold Walmsley pictured with Harford County science students during their recent visit to Arsenal: (L to R) Sandra Hines of Bel Air, Marlene Peroutka of Aberdeen, and Donald Brand of Bel Air.

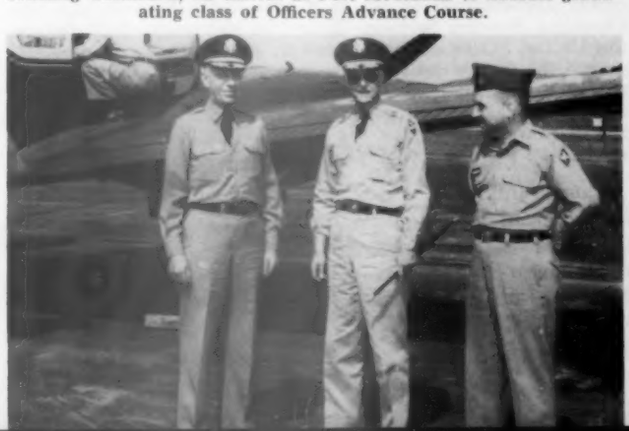
FORT BRAGG, N.C.—Wall of flame created by troops of the 82nd Airborne Division using 50 portable flame throwers in training exercises. Picture taken several years ago recently resurrected in publicising Chemical Corps' 40th Anniversary.

CAMP MERCER, Korea—Brig. General James P. Hannigan, Commanding General Eighth U.S. Army Support Command, speaking at dedication ceremonies at the U.S. Army Chemical Depot. The Camp was named in memory of 1st Lieut. John A. Mercer, winner of the Silver Star, killed in action in Korea, August 9, 1950. Second from right, Maj. Kingsbury T. Jackson, CO. Camp Mercer.

ARMY CHEMICAL CENTER, Maryland—Colonel William J. Allen, Jr., (right) Commanding Officer, Engineering Command, discusses agenda for 2-day symposium for "Quality Control in the U.S.R.R." with Mr. Joseph A. Gwyer of the Library of Congress. Colonel Allen has since been assigned as C.O., Rocky Mountain Arsenal.

DUGWAY PROVING GROUND, Utah—Unique electronic controlled exhibit complete with push-buttons, provided for Armed Forces Day Celebration, includes sound apparatus, tape-recorder, color slide projector and other ingenious devices—designed by W. E. Black; picture drawn by Pfc. William H. Curry.

FORT McCLELLAN, Alabama—Brig. General Marshall Stubbs, (left) commanding First Logistical Command, Fort Bragg, N. C. is greeted by Col. Carl V. Burke (center) commandant Chemical Corps School, and Col. S. Julian Boyles, deputy commander, Chemical Corps Training Command, on arrival at Fort McClellan to address graduating class of Officers Advance Course.



Dr. Winfred O. Milligan, Professor of Physical Chemistry, Rice Institute, Houston, Texas, the new Chairman of the Committee (ACS) Advisory to The Chemical Corps, Dr. Milligan, an outstanding research chemist and industrial consultant, is a specialist in X-Ray studies, electronic diffraction, surface chemistry, catalysis and other special fields.

AMERICAN CHEMICAL SOCIETY

(Continued from page 18)

loyalty and untiring service. Our organization bears the proud title, 'The American Chemical Society,' and whatever America's call may be its chemists stand ready to respond."

Continuing, Dr. Price said that in January 1918, it was announced that the War Department had established a new division attached to the General Staff and designated the Chemical Service Section of the National Army, [also providing for] the erection of a chemical organization for service with the American Expeditionary Forces in France.

The most significant feature in the formation of this Section was the growing appreciation of the value and necessity of chemistry in modern warfare. This unit would serve as advisor to General Pershing on chemical matters and would be attached to his staff through Col. A. A. Fries, head of the Gas Warfare Division. Able scientists throughout the country responded to this call.

Dr. Price said that an editorial appeared in the March 1918 issue of "Industrial and Engineering Chemistry," urging the appointment of a man "pre-eminent among the chemical leaders of the country to act as a coordinating agent for the multifarious chemical activities . . ."

On May 24 1918, Lt. Col. Marston T. Bogert of the Chemical Service Section wrote to Dr. Charles L. Parsons, Secretary of the Society,

"From this memorandum I note that a routine mode of procedure has been agreed upon whereby the American Chemical Society and the Chemical Service Section will cooperate in order to keep in touch with every available chemist in the country.

"May I take this opportunity to express to you my sincerest appreciation of all that you have done to aid the Chemical Service Section. When, in February 1917, before the United States entered the war, you, with rare foresight, sensed the future course of events, and began taking a census of our chemists, few of us realized how speedily such a census would be needed nor how dependent we would be on your records for the successful prosecution of our work. . . ."

Continuing, Dr. Price said that on 25 June 1918, by order of President Wilson, the Experiment Station at American University, Washington, D.C. (gas warfare research) was transferred from the Bureau of Mines to the War Department for operation under the Director of Gas Service of the Army, Maj. Gen. William L. Sibert. Although the Society had hoped that the President would leave this organization in the congenial atmosphere in which it began, it stood behind the decision and urged all American chemists, soldiers and civilians, to continue to give this work their patriotic support.

On 28 June 1918, in General Orders No. 62, the Chemical Warfare Service was created.

In 1917, due to the foresight and energy of Dr. Charles L. Parsons, a census of the chemists of the United States was taken by the Bureau of Mines and the ACS. The census was of incalculable value in the prosecution of the war. Colonel Sibert wrote "without it the present state of progress of the United States in chemical warfare would have been impossible of attainment." In 1918, General Sibert came to the Society with a request for another census, and was given every cooperation.

The Chemical Service Section of the National Army was the first organized military body established for the sole purpose of relating chemistry to warfare. It took as its insigne an old alembic of alchemy joined with the theoretical benzene ring which has so greatly accelerated the development of modern chemistry. It further adopted for its colors those of the ACS—cobalt-blue and gold.

In May 1919, in a report of the Society's Advisory Council, it was stated: "Grave apprehension was felt over the action of the War Department in so quickly demobilizing the Chemical Warfare Section," and a committeee was appointed to urge upon the proper authorities the necessity of the continuance, in an intensive form and under a distinct organization, of chemical work as affecting the Army.

In the January 1920 issue of "The Journal of Industrial and Engineering Chemistry" a stirring editorial, entitled, "Chemical Warfare Service Endangered" appeared. It seemed that the Chemical Warfare Service was in danger of being made a subordinate division of the Ordnance Corps. General Pershing, in his testimony before the Joint Committee of the House and Senate, said the following:

"I think it (Chemical Warfare Service) should be developed, and it would be developed better under a separate organization than under any other bureau. There is no doubt about that.

(Continued on page 30)

Dr. Charles C. Price, of the University of Pennsylvania, retiring chairman of the American Chemical Society's Advisory Committee to the Chemical Corps, receiving Army citation for Meritorious Civilian Service presented at the annual meeting of the Committee at Army Chemical Center on May 20, 1958, by Post Commander Brig. General Harold Walsmley. The citation is signed by Maj. General William M. Creasy, Chief Chemical Officer.

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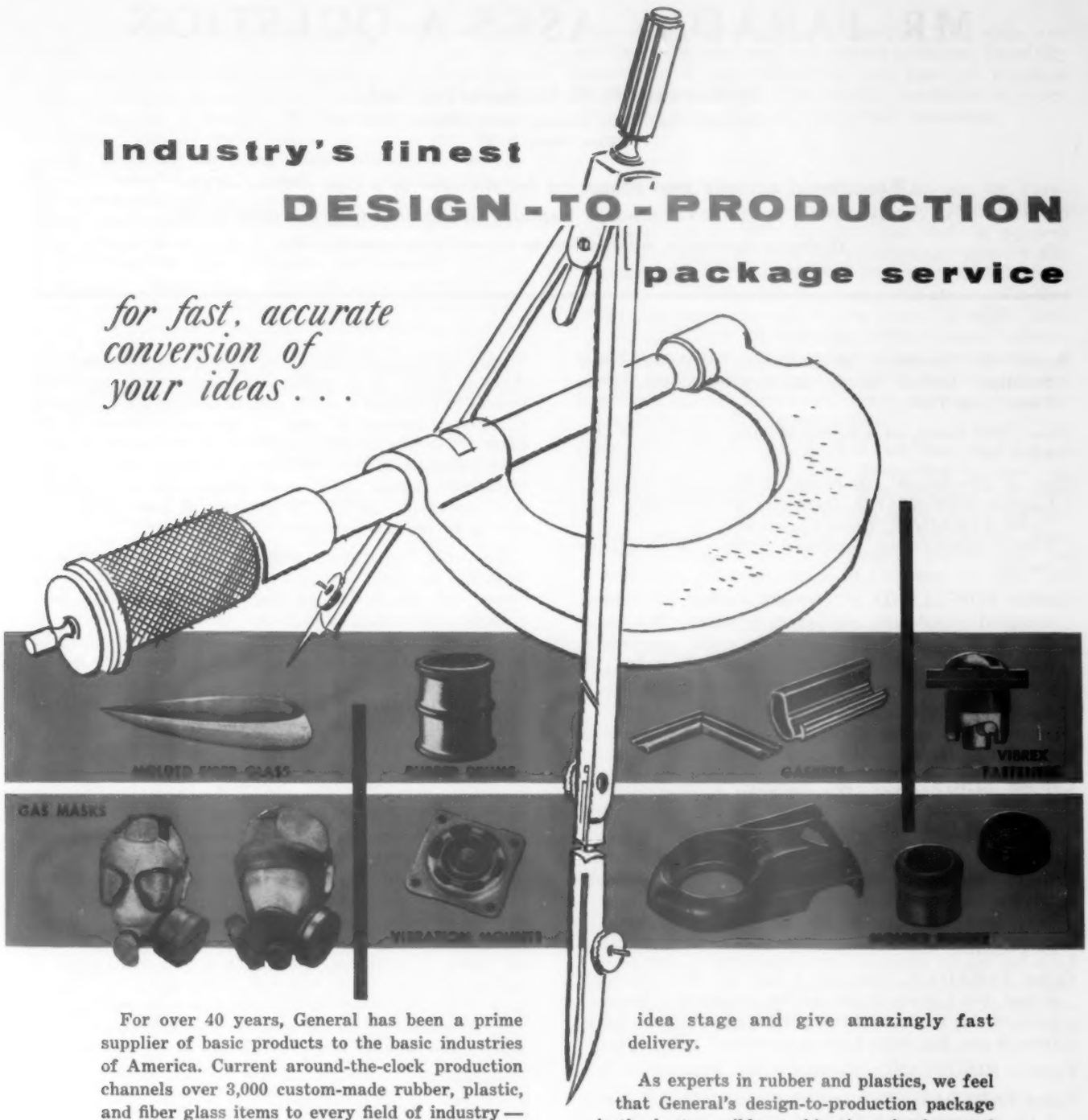

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MR. FARADAY ASKS A QUESTION

By CAPTAIN E. M. GERSHATER, Cml.C.
Chemistry Instructor, United States Military Academy
West Point, N. Y.

(Why should a young man preparing for a career as a Line Officer of the Army bother to study Chemistry? Captain Gershater, using a hypothetical dialogue approach, undertakes to answer that lament.—Ed.)

Scene: A Chemistry Section-Room, East Academic Building, United States Military Academy, West Point, New York.

Time: 0915 hours, on a sunny Monday morning in October 19—.

Cast of Characters (in order of their appearance):
Captain RINGSTAND, Instructor in Chemistry
Cadet FARADAY, Third Classman
Twelve other cadets, members of the —th Chemistry Section

Captain RINGSTAND: . . . so we see that the volume occupied by this gas, gentlemen, is exactly 22.4 liters. Are there any other questions? Very well, gentlemen, that's all for today. Oh, Mr. Faraday, would you please see me for a moment before you leave?

Cadet FARADAY: Yes, sir.
(Twelve other cadets file out of the section-room, to appear no more in this drama.)

Captain RINGSTAND: Mr. Faraday, I am somewhat concerned over your daily grades in the past several lessons. Is Chemistry giving you some difficulty?

Cadet FARADAY: Well, yes, sir, it is. I don't understand these gas laws very well, and I have trouble solving the problems.

Captain RINGSTAND: Have you ever had any Chemistry before, Mr. Faraday?

Cadet FARADAY: Yes, sir, I had a course in high school, but I guess it was pretty elementary, because a lot of this material we're studying now seems quite new to me. Sir, may I ask a question?

Captain RINGSTAND: Certainly, Mr. Faraday.

Cadet FARADAY: Well, sir, what good is . . . I mean, if I'm going to be an Infantry platoon leader—I hope Infantry will be my branch, sir, when I'm commissioned—I won't need all this chemistry theory, I'm sure. The gas laws are bad enough, but I was talking to a First Classman the other day, and he informs me it really gets rough when we get into ionization constants, pH, solubility product, and oxidation potentials. Why will I, as an Army officer, need all that detailed knowledge? Wouldn't our time be better utilized, sir, studying weapons and tactics and the art of command? I mean no disrespect, sir, but I don't quite see the emphasis on this Chemistry stuff.

* * *

Mr. Faraday's question is a reasonable one and deserves a reasonable answer.

To the USMA cadet aspiring to be a professional Army officer, many scholastic challenges are presented during his four-year period of training at the Academy. Among these is a rather comprehensive beginning course in Chemistry, quite comparable to the Freshman Chemistry courses in most of the universities of the land. While strong arguments can be advanced to support inclusion in the curriculum of most scientific and technical subjects, the several advantages of the Chemistry course in the USMA program of instruction may not be so readily apparent.

Certainly the primary objective of an education is to train the recipient to think logically, to distinguish between fact and fiction, to observe facts and draw reasonable conclusions therefrom—in short, to utilize to the fullest the basic intellectual capacity with which he is endowed. Accumulation of factual knowledge is important and should not be minimized, in view of the international climate in which we live today, but long after the developments of an advancing technology have demolished much of the factual information so laboriously (and sometimes painfully) acquired, the power to *think*, independently, logically, progressively, remains unshaken.

In a broad sense, a familiarity with the physical sciences, an appreciation of the natural phenomena of the universe, constitute items of significant cultural value. From early childhood, consciously or unconsciously, humans acquire a mental storehouse of scientific facts: sugar tastes sweet, gasoline is highly inflammable, acids eat holes in clothing, butter has a vile odor when it spoils, and hard water will not form lathers with ordinary soaps. Important as these facts are, no student can hope to assimilate the myriad of such facts known unless he can classify such knowledge in an orderly and intelligent fashion. What is essential is an intellectual *point-of-view* about these matters, the striving for understanding by an inquisitive and eager mind.

It is perhaps easier, initially, to specify what the objective of the USMA Chemistry course is *not*. It is not the training of chemists. That task is better accomplished in the graduate colleges of the land, and the Army's needs for such trained specialists are filled adequately through the graduate training program. The number of USMA graduates (as well as other Regular Army officers) who have pursued graduate programs of instruction in chemistry, let alone in the remaining physical sciences, and have been subsequently assigned to utilization-tours, is now a quite respectable figure.

The major objective of the USMA Chemistry course can probably best be summarized as the attempt to stimulate those basic intellectual processes which man must employ to analyze and solve an existing problem. This objective—which is hardly unique to the Chemistry instruction—aims to impart to the students, through sound pedagogical techniques, those mental

tools which will serve the Army officer throughout his career.

Chemistry at the Military Academy is a one-year course, presented during the cadet's second, or yearling, year. Fifty-one recitations, 18 laboratory experiments, 6 lectures, and 17 examinations comprise the eight-month program, including basic instruction in the physical states of matter, solutions, chemical equilibria, the descriptive chemistry of the more important elements, oxidation-reduction mechanisms, electrochemistry, organic chemistry, metallurgy, and nuclear chemistry. Throughout this instruction, the scientific method is stressed: Observation of facts, and correlation of those facts into reasonable conclusions. All work, both in the section-rooms and in the laboratories, is individual; written daily quizzes and laboratory-reports require the cadet to report on paper his responses to specific questions designed to test his understanding of the principles studied.

How well are these laudable objectives realized? During the study of solutions, a cadet was asked to describe the probable effect of adding a crystal of cupric sulphate to a solution already saturated with cupric sulphate; his reply was, substantially, "Since the solution is saturated in the first place, it's already holding as much cupric sulphate in solution as it possibly can at that temperature. Therefore, I believe the extra crystal added would just drop to the bottom of the beaker and sit there and look at you." Again, asked to explain the rapid evolution of carbon dioxide gas when salt is added to a glass of beer, a classmate of our first cadet replied, "The sodium and chloride ions of the salt tie up water molecules—more properly stated, they become hydrated—this means that those water molecules are no longer available to hold the CO_2 in solution. The CO_2 molecules, therefore, no longer have a home, and out of the solution they come." Oversimplifications these certainly are, but they do reveal, happily, a basic understanding of *concepts* and an ability to reason from observed effect to probable cause.

An important segment of the program is designed to give the student an insight into practical military applications of the principles studied. When the cadet understands the heat of reaction of combustion-reactions and the formation and behavior of colloidal gels, he will appreciate more the principle of operation of flame-thrower weapons. When he examines nylon armor vests worn in battle, which blocked the passage of shell fragments, and when he notes the improved explosive-charge-to-total-weight ratio of the new polyester-fiber-glass plastic mine, he is increasingly acquiring a mental design for the transformation of chemical knowledge from interesting scientific curiosities into useful military developments. Through the practice of the scientific method, through exposure to the wealth of knowledge gradually acquired by inquisitive, reasoning men, the application of chemistry to national defense, to industry, and to every-day life become most real to young men who have perhaps infrequently before reflected on the explanations of natural phenomena.

The Military Academy trains the *Army* officers, not the *branch* officers, of the future. The newly-commissioned graduate is not specifically nor likely to be a qualified Artillery officer or Engineer officer; branch-qualification is accomplished at the branch service schools, and it must necessarily be so. The Military Academy strives rather to produce the educated man, the disciplined mind, the officer equipped by intellect and by personality to lead men, to contribute to the Army's mission, and to grow and develop under the stimulus of increasing responsibilities. The tools and techniques of analyzing and solving problems, hopefully acquired and strengthened in four years of intensive mental calisthenics, remain useful line-items in every graduate's inventory of intellectual capacities.

* * *

Captain RINGSTAND: . . so I hope you see, Mr. Faraday, not only that Chemistry is very far from being an abstruse scientific curiosity, but that our purpose in including it in the USMA curriculum is quite different than making qualified laboratory chemists out of you cadets. I think it is important to add also that virtually every branch of the Army is vitally concerned, directly or indirectly, with chemical science and technology. Let me mention just one example, of great importance in today's Army: the development of fuels for our rocket and missile program is simply a task in chemical investigation.

Cadet FARADAY: Yes, sir, I do see that. And I must concede that I find it very interesting to learn the explanation behind many of these things. I just seem to have so much difficulty with some of the material that I sometimes get pretty discouraged. In fact, when I see the way some of the 'hives' in the class eat this stuff up, I only feel qualified to sweep the floor and clean the equipment in here.

Captain RINGSTAND: You should not become discouraged, Mr. Faraday. A man who possessed your identical surname, Michael Faraday, as a young man, almost 150 years ago, worked in the laboratory of Sir Humphrey Davy, then the most illustrious chemist in Europe, and initially his duties were just that, sweeping the floor and cleaning the equipment, at a salary of 25 shillings a week. But he didn't stay in that classification long; he grew and developed rapidly, and it was not long before he was touring Europe with Davy, as his assistant, helping him give lectures and demonstrations of chemical principles to enthusiastic audiences. So successful was he that it has been said that where people respected and admired Davy, they worshipped Michael Faraday. And his name today certainly is included among those of the greatest scientists of all time, a man to whom we are indebted for much of our fundamental knowledge of electricity and electro-chemistry, and whose papers remain today a model of acute observation and lucid writing. By the way, Mr. Faraday, are you related to this most brilliant man?

Cadet FARADAY: (grinning broadly) I should say, sir, that the odds are all against it.

Captain RINGSTAND: Never say die. Learn and understand the *principles* we are studying, and the rest will come to you rather easily. Most of the mathematical computations you are required to make involve little more than simple proportion—you know, if John is 12 years old, and Bill is twice as old as John, how old is Bill? Except that we say, if 12 grams of carbon react completely with 32 grams of oxygen, how many grams of carbon are needed to react completely with 96 grams of oxygen. How are your roommates doing in Chemistry?

Cadet FARADAY: Quite well, sir. And both of them are coaching me, so I'm determined to understand this stuff. I don't believe, however, that there will ever be two famous Faradays in the scientific literature.

Captain RINGSTAND: You never can tell, Mr. Faraday, you just never can tell. . . .

BIOLOGICAL WARFARE AND ITS DEFENSE

(Continued from page 6)

bered, however, that there are many agents for which there is no solid immunity and a partial or low-grade immunity may be broken by an appropriate dose of agent.

There is a broad spectrum of agents from which selection for a specified military purpose might be made. An enemy might choose an acutely debilitating microorganism, a chronic disease producer or one causing a high rate of lethality.

It is possible that certain mutational forms may be produced such as antibiotic resistant strains. Mutants may also be developed with changes in biochemical properties that are of importance in identification. All of these considerations are of critical importance in considering defense and medical management.

Biological agents are, of course, highly host-specific. They do not destroy physical structures as is true of high explosives. This may be of overriding importance in considering military objectives.

The question of epidemic disease merits some discussion. Actually, only a limited effort has been devoted to this problem in the research and development program. Some of those who question the value of BW have assumed that the only potential would be in the establishment of epidemics. They then point out that with our present lack of knowledge of all the factors concerned in the rise and fall of epidemics, it is unlikely that a planned episode could be initiated. They argue further (and somewhat contradictorily) that our knowledge and resources in preventive medicine would make it possible to control such an outbreak of disease. We agree with this in general, and this is why this approach to BW defense has not been given major attention in the program.

Our major problem is what an enemy might accomplish in an initial attack on a target. This, of course, does not eliminate from consideration for this purpose agents that are associated naturally with epidemic disease. A hypothetical example will illustrate this point. Let us assume that it would be possible for an enemy to create an aerosol of the causative agent of epidemic typhus *(Rickettsia prowazwki)* over City A and that a large number of cases of typhus fever resulted therefrom. No epidemic was initiated nor was one expected because the population in City A was not lousy. Lousiness is a prerequisite for epidemic typhus. In this case, then, the military objective was accomplished with an epidemic agent solely through the results secured in the initial attack. This was done with full knowledge that there would be no epidemic. On the other hand, a similar attack might have been made on City B whose population was known to be lousy. One might expect some spread of the disease in this case resulting in increased effectiveness of the attack.

OUR major defensive problem is concerned with the possibility of overt military delivery of biological agents from appropriate disseminating devices. It should be no more difficult to deliver such devices than other weapons. The same delivery vehicles—whether they be airplanes, submarines or guided missiles—should be usable. If it is possible for an enemy to put an atomic bomb on a city, it should be equally possible to put a cloud of biological agent over that city.

Biological agents are, moreover, suitable for delivery through enemy sabotage which imposes many problems in defense. One can let one's imagination run wild in this regard. One might mention a few obvious areas—however, of great importance. The air conditioning and ventilating system of large buildings are obvious targets. America is rapidly becoming a nation that uses processed, precooked and yes! even predigested foods. This is an enormous industry that is subject to sabotage. One must include the preparation of soft drinks and the processing of milk and milk products. Huge industries are involved also in the production of biological products, drugs, and cosmetics which are liable to this type of attack. These few major areas have been mentioned since sabotage in them would be far-reaching in its consequences. Furthermore, all are subject to prophylactic defensive action.

Another aspect of biological warfare is the possible use of biological agents for the reduction of, or destruction of, agricultural crops and domestic animals—in other words, antifood biological warfare. The importance of food, particularly during war, needs no emphasis. Actually food production is of major concern to most countries even during peacetime. Ours is one of the few countries in the unusual position of finding overproduction a major problem.

In all wars, moreover, military efforts have been devoted to the destruction of the enemy's food supply. The grain-laden freighter was as much a prize for a submarine as a ship loaded with tanks.

Biological warfare may find its greatest effectiveness when used for anticrop and antianimal purposes. Contrary to the case of antipersonnel BW, the epiphytotic and epizootic potential of anticrop or antianimal agents would be exploited by an enemy. Antifood biological warfare could play a decisive role in any war that was not decided with push-button speed. This country is in a favorable defensive position in anticrop warfare. Our cropping is very diversified and biological agents are, of course, specific for particular crops. Those countries that are generally dependent, for agronomic, climatic or traditional reasons, on a single crop, are the most vulnerable.

It is hoped that this general consideration of biological warfare will serve as a useful framework around which one can fashion one's defensive thinking and planning. I will not discuss defense in detail. This will be accomplished by other speakers during this conference. I would like to outline briefly, however, certain broad principles in relation to defense.

It may seem trite, but nevertheless it is worthwhile to emphasize, that there is a vast amount of medical knowledge in existence which can be useful. In this sense BW is not completely new. We have had long medical and epidemiological experience with infectious diseases. We have a vast public health effort in being at the federal, state and local levels. Our sanitary engineering practices and methods for disease control are at a high level of efficiency. All of these are positive values in our defensive bank account which can be drawn upon in an emergency and would be of great value.

ONE must not be complacent, however, and be lulled into thinking that BW would be rendered ineffective by these aids. This is not so. I cannot emphasize the following point too forcefully. May I point out that these marvelous techniques of preventive medicine were developed over the years for dealing with *naturally* occurring infectious disease. The military exploitation of massive amounts of highly infectious agents through unusual portals of entry creates new problems for which these procedures were not designed and against

(Continued on page 28)

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BIOLOGICAL WARFARE AND ITS DEFENSE

(Continued from page 26)

which no experience has been developed. One might illustrate this point. Adequate means have been developed, for example, for delivering potable water to all inhabitants in a community. We now take this for granted. On the other hand, there is no known public health procedure that will deliver sterile air to all inhabitants of a city. Defense against a massive biological aerosol is a new and critically serious problem.

One of the most critical problems in defense is detection or early warning. Biological clouds have no characteristics detectable by the senses. They are invisible, odorless and tasteless—in contrast to certain gas clouds. The importance of immediate detection and warning is that it may permit certain defensive actions of a physical nature. The gas mask, for example, affords excellent protection to the respiratory tract if it can be put on in time. Early warning may also permit timely entrance into collective shelters should they exist. It is possible to design quite efficient structures for this purpose. Some progress is being made in the development of instrumentation for rapidly detecting unusual concentrations of particulate matter in the air.

A closely related problem is rapid specific identification of the particular agent. The ordinary biological methods employed in the diagnostic laboratory are far too slow. Identification of viruses is especially tedious. Progress is being made in this field, but much remains to be done. One might suggest at this time that any laboratory conducting research to improve and speed up identification of disease-producing organisms will be making a significant contribution to the defense effort.

It is important, too, to maintain an adequate epidemiologic intelligence service and warning network. An unusual occurrence of disease in a particular location may be the first warning of a BW attack, particularly if it is of sabotage origin. The prompt recognition and reporting of such episodes is essential.

It is also important to have available the services of an organized network of laboratories having the qualifications and equipment necessary for the recognition and identification of unusual agents. Such services are needed particularly in the virus field. The personnel in such laboratories should be trained and indoctrinated in those features of BW that may have a special bearing on their responsibilities. This should include training in the use of new detection devices and procedures for rapid identification of agents, especially in specimens obtained from the environment where contamination is extensive.

ONE of the most important of all defensive procedures is prophylaxis by active biological immunization. A number of effective immunizing materials are already available for some infectious diseases. On the other hand, there are a number of potential BW agents against which there is no method of immunization. There are many instances also where the value of the immunizing material continues to be questionable or at least where improvement must be sought through more research. One must encourage all research possible that is devoted to the development of new, or improving existing methods of active immunization. All ancillary research dealing with host-parasite relationships will have positive defense value. Moreover, all such research has great peacetime value. It will not be totally consumed in an engine of war.

The administrative problems in connection with the immunization of large populations against a number of agents are enormous. This, too, is an area where research should be fruitful because simplified techniques for rapid, mass immunization are essential. Considerable effort is being devoted to the development of combined or multiple vaccines; an effort that is being rewarded with some success.

There are many additional aspects of BW defense relating, in particular, to the medical management of large numbers of casualties. I shall not discuss these very important problems since other speakers will deal with them.

I should like to conclude my discussion with a few words concerning prevention of sabotage. A careful vulnerability study should be made of all sensitive industries and facilities to determine the most likely spots for attack. During an emergency there should be proper policing and guarding of such spots. Loyal employees should be indoctrinated to the point of being able to augment such guarding. Air conditioning and ventilating systems of sensitive buildings should be appropriately protected. Adequate chlorination of water supplies should be assured.

I hope this general discussion of biological warfare will serve as a framework upon which you can construct the details of your defensive thinking and planning.

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THE MANUFACTURE OF MUSTARD GAS

(Continued from page 17)

flowed into the River Rhone. Moreover, all the sulfur dichloride could not be removed from the mustard gas. This impurity reacted with the liquid (particularly after it was filled into iron containers) introducing more chlorine into the molecule, and thus rendering the substance relatively harmless. I doubt if the shell as actually fired had an offensive value of over 50 per cent. The English munitions department consistently refused to load shell with material of this grade. If the Americans, who had to figure on three months elapsed time from filling plant to battery, had adopted the same process, I think their shell would have become nearly worthless before being fired. Yet it is only fair to say that the French had the nerve and energy to go ahead and do something while the other nations were still feeling around. Over three-fourths of the mustard gas shell fired by the Allies were filled with material from the Usines du Rhone.

I took advantage of a three-day shutdown for repairs at Roussillon to go to Pont de Claix and visit the mustard gas plant of the Compagnie Chlore-Liquide. Conditions there were about as different as they well could be from those at Roussillon, but the plant was in its way no less interesting. Perhaps the most remarkable part about it was the fact that the sum of the ages of its three moving spirits was less than 90 years. Motte, the director, was a member of a famous family of French industrialists who manufactured textiles in the north of France. Driven out by the German advance, he had come down to this forgotten little hole, and, with the help of some financial backing from Paris, had started a small factory for the manufacture of liquid chlorine.

As Pont de Claix lies right in the mountains, it is excellently supplied with water power. But for that fact, it would be impossible as a plant site, because in every other respect it is extremely inconvenient. Far removed from the great industrial centers, supplies were almost impossible to get. Indeed, the results obtained by the Chlore-Liquide are an eloquent illustration of what three intrepid spirits can do in the way of overcoming want of material and government indifference. Valves, for example, were not to be thought of. You either made them yourself, as Lichtenberger, their combined chemist and engineer did, or you went without. Baert, the lieutenant in charge of the shell-filling plant, rigged up a filling machine with which he managed to fill four shells a minute. Moreover, from the time he installed this device, he never had a blistered hand or a sore eye in his shop. Yet his contrivance was built entirely of old junk picked up on the factory scrap heap. I am sure it could have been duplicated out of new material for $200.

Some months later, after I had returned to the United States, I had occasion to think of Baert's little machine. I was shown over the mustard gas shell-filling plant at Edgewood Arsenal, which was filling 18 shells per minute. Asked what I thought of it, I said it was superb—which was the truth. But it must have cost at least $50,000.

The Chlore-Liquide used a very simple process. They bubbled ethylene under pressure through sulfur monochloride. The unabsorbed gas was pumped back into the pressure tank and used again. The apparatus was extremely inexpensive, the only specially designed unit being the absorber. Ethylene was made in furnaces borrowed from the Usines du Rhone. The working force suffered terribly because of sulfur deposition. By the time I visited them, a new type of valve, which they had designed and built themselves, had obviated most of the clogging of the pipes; but Lichtenberger told me that the early days of the process had been one long agony. Certainly he and his assistant were two of the most pitiable objects I have ever seen. At the moment, they were just in the throes of attempting to filter the solid sulfur out of the finished product. As these attempts failed completely, they were finally reduced to the necessity of settling their mustard gas in drums. The clear liquid was then drawn off to be put in shells, and the drums were refilled. Gradually, of course, the drums became full of that deadly paste. They were then rolled out to the river bank and discarded.

The capacity of the plant was small—not, I think, over half a ton a day, but the quality was excellent. Practically no uncombined sulfur monochloride was left in the liquid, so that, once in the shell, the gas showed very little tendency to decompose. At first, the process was run at 70° Centigrade, but gradually the working temperature was lowered, thus bringing the method closer to what was found in England to be the best practice.

Even further progress along this line was made by the only other mustard gas plant I know of in France, that of the Société de Stéarinerie at Lyon. Unfortunately, their factory was shut down while I was in the neighborhood, and so I did not see it. All I know about it is that it was a monochloride process which worked at low temperature, and suffered very little from sulfur deposition. It operated only intermittently and never produced much material.

(To Be Concluded)

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AMERICAN CHEMICAL SOCIETY

(Continued from page 22)

"The Chief of Ordnance does not know anything about it, and he does not want it, as far as that is concerned. The Chief of Ordnance, I have no doubt, would give it every attention. But it is not in his line, and he could not give it the attention that it should be given; he would not draw to his aid the chemists of the country so readily as some man who had been closely associated with the Chemical Warfare Service would do. That is a very important matter, because it would be a department of investigation."

The editorial also said ". . . General March, in his Annual Report, gives the clinching argument in favor of a highly developed Chemical Warfare Service. He points out that the chief lesson of the war is the necessity of having the nation so organized in peace that its entire resources may be instantly and effectively mobilized for war. . . .

"How can this unfortunate move in the House Committee be met? . . . Responsibility in this matter rests primarily upon us. Our membership reaches into every Congressional district. It is time to get into the saddle again and to do so quickly. Let our people and our Congressmen know what this new move means."

Another editorial, entitled "Critical Days," appeared in the February 1920 issue, and stated: "Public opinion, however, must be informed regarding these measures in order to rouse itself to unmistakable expression, and that is the responsibility of the chemists of America."

The Army Reorganization Bill passed the House of Representatives on 18 March 1920, and contained a section providing for the CWS as a separate unit of the Army.

At the Sixth National Exposition of Chemical Industries, September 1920, Dr. Charles H. Herty, Chairman of the ACS Advisory Committee, said:

"Now let me make an announcement of greatest import to our country. The Congress, during its last session, in framing the Army Reorganization Bill, constituted by an overwhelming vote the Chemical Warfare Service a separate and independent unit of the Army, in the conviction that it could thus be developed most effectively. At its head the President has placed that brilliant soldier, Brigadier General Amos A. Fries, who led the field forces of that Service with the American Expeditionary Forces. Upon invitation of General Fries, the American Chemical Society has pledged the active aid of its 15,000 civilian members in the successful development and prosecution of the work of the Chemical Warfare Service. The connecting link between that army of 15,000 silent workers in the laboratories of America and the official service in the War Department will be a committee consisting of:

"*W. D. Bancroft*, Dept. of Chemistry, Cornell University, Ithaca, N.Y.; *E. P. Kohler*, Dept. of Organic Chemistry, Harvard University, Cambridge, Mass.; *A. B. Lamb*, Dept. of Chemistry, Harvard University, Cambridge, Mass.; *R. C. Tolman*, Fixed Nitrogen Research Laboratory, Washington, D.C.; *F. M. Dorsey*, Nela Research Laboratory, Cleveland, Ohio; *W. K. Lewis*, Dept. of Chemical Engineering, M.I.T., Cambridge, Mass.

Bradley Dewey, Dewey & Almy Chemical Co., Cambridge, Mass.; *L. C. Jones*, National Aniline & Chemical Co., Inc., N.Y.C.; *C. L. Reese*, E. I. du Pont de Nemours & Co., Wilmington, Del.; *W. H. Walker*, Division of Industrial Cooperation and Research, M.I.T., Cambridge, Mass.; *Reid Hunt*, Dept. of Pharmacology, Harvard Medical School, Boston, Mass.

A. S. Levenhart, Dept. of Pharmacology, University of Wisconsin, Madison, Wis.; *Julius Stieglitz*, Dept. of Chemistry, University of Chicago, Chicago, Ill.; *Chas. H. Herty*, Journal of Industrial and Engineering Chemistry, N. Y. C. . . ."

The third panelist to discuss the 1917-1920 period was Dr. Harold C. Weber, Professor of Chemical Engineering at Massachusetts Institute of Technology. Dr. Weber is a member of the Secretary of Defense Panel on CW-BW; Chairman of the U.S. Army Chemical Corps Advisory Council; and consultant on problems of chemical warfare, petroleum, thermodynamics, and electronics.

Dr. Weber showed some very good slides [of] the participation of the American University Washington, D. C., in the early work of the Chemical Corps. . . .

Dr. E. Emmet Reid presented highlights of this period. Dr. Reid, Emeritus Professor of Chemistry, The Johns Hopkins University, is consultant for Du Pont, Army Chemical Center, Hercules Powder, and many other nationally-known industries and Government installations.

Dr. Harold S. King, Scientific and Technical Advisor, Chemical Corps Board, Army Chemical Center, Maryland, also discussed this period. Dr. King was a research chemist for Du Pont from 1918 to 1919; chief chemist and chief inspector of Ordnance, U.S. War Department, Volunteer Ordnance Works, Tennessee, 1942-1944.

Dr. King told of the benefit derived by the gasoline industry from World War I Chemical Warfare research. In 1918, while he was working with Professor Richards at Harvard on the isotopes of lead, and investigating the fractional diffusion of tetramethyl lead, he noted in literature that there was considerable interest in organo-lead compounds in Germany. In view of the action of these compounds on the nervous system, he reported to the U.S. Committees the possibility that the Germans might be interested in these compounds as war gases.

Some years later, Dr. Midgley told Dr. King that he had taken up the problem and worked out a method of preparation of sufficient quantities of tetraethyl lead for CW tests. Then still later, when investigating knocking in internal combustion engines, Dr. Midgley remembered this wartime research and tried tetraethyl lead. It was found to be an effective antiknock agent.

Mr. Earl P. Stevenson, also a panelist for this period, is president of Arthur D. Little, Inc., Cambridge, Mass. Mr. Stevenson's contacts with the Chemical Corps date from 1917 when he served as a Captain, and he has been associated with the Corps' activities since that time. He discussed the period 1920-1938 when special attention was given to organizing for research the peacetime projects carried on during these years, together with development, procurement and mobilization plans of the period. Emphasis then was given to the struggle for existence as a separate service, followed by the more critical struggle for mere existence during these years. He told of the assistance of other agencies and services in maintaining the Chemical Corps and the relationship of the American Chemical Society Committee to this struggle.

Dr. Charles G. Overberger, another panelist of this period, is Professor of Organic Chemistry, Polytechnic Institute of Brooklyn, New York. He is a member of the committee for discovery of new ideas of Chemical Corps interest formerly headed by Dr. Kharasch who recently died.

Dr. Overberger referred to the numerous articles citing instances in which the Society "mounted the platform" to discourage the ratification of what it considered to be unhealthy treaties against the use of chemical warfare. Quoting the resolution prohibiting chemical warfare passed on 7 January 1922 by the Committee on Limitation of Armament, he noted the Society, with ever-alert vigilance, immediately informed the membership of this. It pointed out that the proposals made simply reaffirmed admitted principles of international law and that a mere *confirmation* of the law, without adding any sanctions to it, could not relieve

the nations from taking precautions against those who are prepared to break the law and who might easily dominate the world by their indifference to law. The editorial on this subject stated:

"It is impossible to prevent a nation bent upon this method of warfare from making its preparations in time of peace, no matter what the rules of war may be. No nation, therefore, can forego the duty of examining how such attacks can be effectively met."

In 1925, he stated, the action of Congress in advancing the Chief of Chemical Warfare Service to the same rank as the other branch chiefs—Major-General—was felt by the Society to be a significant step forward. But notwithstanding this victory for chemistry, when compared to the level at which other nations were funding their chemical-warfare efforts, our funding was lacking.

"The present Committee," Dr. Overberger continued, "has been extremely interested in another area—that concerning the travel of Government scientists to scientific and professional meetings." He said that although the present membership may not realize it, the support on this matter dates from 1924.

Even in 1922, he noted, the inadequacy of Government salaries paid to scientific personnel was of concern. The efforts of the American Chemical Society and other organizations and agencies were rewarded when, in 1923, compensation for the professional and scientific service of the Government was raised.

Dr. Vernon H. Cheldelin, Professor of Chemistry and Director of the Science Research Institute, Oregon State College, Corvallis, Oregon, an authority on vitamin assay methods, author of a paper entitled "Sputnik and American Science," which appeared in the Congressional Record, February 5, 1958, discussed the mission of the Chemical Corps, its development, toxicological warfare and by-products, the Corps' contributions to medical science.

At the time of its permanent formation, the mission of the Corps dealt only with the smoke, incendiary, and gas aspects of chemical warfare. Through the years many changes have been made. Today, the broad general mission of the Chemical Corps is to study and investigate toxicological warfare. Biological warfare was added during World War II, and radiological warfare shortly after that war. In addition, the Corps must provide technical supervision of the military training in these fields, and develop, manufacture, procure and supply materiel and equipment.

The Corps' position in the development field is unique in that most of its items are for use by all of the armed forces—the Army, the Navy, the Marine Corps, and the Air Force. Also, civil defense must be included, for it is in this type of planning that some of the Corps' defensive developments are being put to use.

While it is true that gas preparedness is a major responsibility of the Corps—and the carrying out of this responsibility undoubtedly deterred the Axis nations from initiating gas warfare in World War II—it must be recognized that "chemical warfare" is an elastic term. Under the present-day aspect it stretches to include many scientific developments and applications that are little known to the general public.

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With respect to Chemical Corps smoke generator units—during World War II, smoke screens made either with mechanical generators, airplane spray tanks, 4.2-Inch Mortar Shells, or burning smoke pots, played an extremely important part in denying enemy observation of our activities. Colored signal smokes, another Chemical Corps product, have played an important role.

Although practically the full capacity of the Chemical Corps is directed toward discovering, developing and supplying the protective equipment necessary to meet the dangers of toxicological warfare, all of this work does not lead merely to advancement in military needs. Often work on a military subject has developed an offshoot project bettering the health and welfare of everyday civilian life. This has been especially true in the field of medicine.

Chemical Corps scientists, working with medical researchers, have found that some war gases can be effectively used in treating certain forms of cancer. Experimentation has also led to a new antidote for arsenic and lead poisoning. A nerve gas, long since discarded as impractical for war use, turned out to be beneficial in the treatment of glaucoma.

The Army Chemical Corps has also played a prominent role in developing a soil-treating agent consisting of the war gas, chloropicrin, which improves the yield of small grains and sugar beets; development of a plastic grenade for tear gas (often used in controlling riots), thus eliminating the dangerous fragmentation effects of the metal grenade; the use of smoke generators to produce fog for the protection of crops against frost, and to put out dense clouds of insecticide smoke and weed killers; considerable data regarding the control of various crop diseases, an outgrowth of studies of possible defenses against an enemy attack with biological agents; the use of shoe impregnite, originally [for] protection against blister gases, to keep out moisture and cold; development, in collaboration with the Canadian Government, of a rapid method of producing large quantities of vaccine against rinderpest; a practical method for using PAPP (para-aminopropiophenone) as a remedy for cyanide poisoning; methods leading to the conversion of napalm into soap for general household purposes; the portable flame thrower adapted for killing weeds; a safe method for fumigation of ships; the 400-gallon, truck-mounted, gas decontamination set for use in spraying insecticides; pyrogel or "goop" (an incendiary bomb filling) for prevention of forest fires; herbicides which can kill broad-leafed plants but not affect most grasses; data on the correlation between chemical structure and activity of insect repellants and attractants.

From Chemical Corps studies in the biological warfare field have also come some valuable contributions to medical science and the national economy, such as advances in the treatment of several infectious diseases, studies of immunity development, increased knowledge of use and effect of antibiotics.

Dr. Cheldelin concluded by stating that the Army Chemical Corps, in its first 33 years of existence, forged a strong link in the national defense chain, and at the same time made important steps toward bettering the health and welfare of mankind.

Dr. William J. Bailey, another panelist, is Professor of Organic Chemistry at the University of Maryland. He received the Fatty Acids Research Award in 1955.

Dr. Bailey first discussed incendiaries, stating that the incendiary arrow is one of the oldest war weapons on all continents. Alexander the Great, in a letter to Aristotle, reported "terrific flashes of flame" showered on his army in India.

"Greek Fire," believed to have contained pitch, resin, petroleum, quick-lime and sulfur, is said to have been invented by the Syrian, Callinicus, about 600 A.D., although there is evidence of the use of similar compositions in the time of Constantine the Great in the 4th century A.D. The Byzantine Empire made such effective use of "Greek Fire" against the Saracens that it is said to have saved that Empire from foreign domination for nearly one thousand years.

In early times, animals and even birds were used in carrying fire to the enemy. In medieval days, covered wooden rams were augmented with projecting containers of blazing material, and floating fire balls were launched against shipping and water battlements. Horsemen sometimes fastened torch-like gadgets in their lances. The armies of the Caliph of Baghdad, in the 12th century, had a special unit of soldiers called "Naphthyns," naphtha pot flingers.

The development of firearms caused armies to engage at greater distances, thus lessening the effectiveness of the early incendiaries. This invited experimentation with incendiaries fired by artillery.

The initial use of incendiaries from aircraft was during the German Zeppelin raid on London in 1915. Subsequent development of the long-range bomber spurred use of the aerial incendiary.

Dr. Bailey next traced the development of flame throwers from the device used at Delium in 424 B.C.

Initial incendiary attacks against ground troops in World War I were introduced by the Germans in 1915. Since that time the flame gun has been considerably improved and the first recorded operations with flame throwers by American troops in World War II was at Guadalcanal in 1942. The U.S. Army flame throwers were designed and developed by the Chemical Warfare Service (now the Chemical Corps).

Discussing smoke, Dr. Bailey stated cavalry had long appreciated the value of dust clouds raised by horses' hoofs to help conceal movement, and, from this, developed the idea of "artificial fog" or smoke for screening troops. As early as 50 B.C., he said, firing of damp straw to smoke out enemy positions was common. History records that Caesar and Pompey used smoke to cover landing operations; Gustavus burned wet straw to screen his crossing of the Lech; the "Blenheim Mist" was utilized by Marlborough in 1704 to surprise a superior force. In 1864 the use of smoke for troop concealment in routing the Confederates was suggested to President Lincoln, but there is no evidence of its usage.

World War I spurred the development of smoke as a troop-screening agent.

The Germans demonstrated the value of smoke in World War II when they blitzed the Low Countries. Between June 1941 and April 1943 they placed smoke over vital ports in Germany, France, Norway, Italy and North Africa. They also screened targets in Poland and Russia, and used smoke for the concealment of ships. In the desperate days following Dunkirk, the British utilized orchard smudge pots to hide vital installations. British smoke came into prominence when World War II shifted to the Middle East. Their first screen in that area was raised over Malta on May 10, 1942.

Smoke has furnished the modern armor for many of our own operations in North Africa, Italy, Europe, and the Pacific and other areas.

With reference to gas, Dr. Bailey continued, the ancient Hindus evolved stinkpots and other chemical fumes as well as means of releasing them upon the enemy. In 429 B.C., the Spartans used a crude form of suffocant against the cities of Delium and Platea. During the siege of Charleston in the war between the States, wood saturated with sulfur was burned near the

parapets in the vain hope that favorable winds would waft the fumes to the defenders.

At the Hague in 1889, and again in 1907, efforts were made to prohibit gas as a weapon of war. Germany, in spite of her pact, used chlorine at Ypres in 1915, and Italy, he stated, though signatory to a 1925 Geneva treaty prohibiting war gas usage, employed mustard gas in the Ethiopian campaign. On six occasions during World War II, the United States formally warned the Axis that any use of gas would bring prompt and effective retaliation.

Dr. Bailey next discussed the 4.2-Inch Chemical Mortar, which, he stated, replaced the Stokes mortar of World War I which was originally designed for use with poison gas and smoke shells.

In concluding his talk, Dr. Bailey said that the responsibility for research, development, procurement and supply of all chemicals for the Army, as well as training of personnel in all aspects of chemical warfare, is vested in the Chemical Corps.

During the period *1938-1946*, the Chemical Corps may be said to have begun its real emergence. The research and development programs of this period were highlighted at this meeting with special reference to agents and munitions, the facilities available, procurement and industrial mobilization problems, as well as the development of specific items of importance. Some of the items of this period include the gas mask and miscellaneous protective items, incendiary bombs, 4.2-Inch Chemical Mortar and shell, flame and smoke. In addition, significant strides were made in medical and toxicological research.

Of particular significance in this period was the work of the CWS Committee and in the later years, the transfer of these committee members to posts more intimately connected with the Chemical Corps through NDRC (National Defense Research Council) and OSRD (Office of Scientific Research and Development) assignments.

Panelists who covered this period were:

Dr. Duncan MacRae, former Chief Consultant, Technical Command, Chemical Warfare Laboratories, Edgewood, Maryland;

Col. C. B. Drennon, Deputy Commander, Army Chemical Center Materiel Command;

Dr. Harlan Worthley, Executive Secretary, BW-CW Coordinating Committee, Office of the Assistant Secretary of Defense for Research and Engineering;

Dr. James Defandorf, Research analyst, National Academy of Sciences, National Research Council, and formerly of the Medical Division, of Army Chemical Center.

To cover the period *1946-1958*, emphasis was given the progress made in the Research and Development program, achievement in facilities, and capabilities of procurement. Highlights of the Committee (ACS) Advisory to the Chemical Corps were cited in terms of the reestablishment of the committee; the use of members as individual consultants and for presentations of seminars.

Panelists to cover this period were:

Mr. Earl P. Stevenson (see 1917-1920 above);

Mr. John Traub, Deputy Director of Supply & Procurement, Chemical Corps Materiel Command, Army Chemical Center;

Dr. John Phair, Professor of Preventive Medicine (1946-1949), and Profesor of School of Medicine, University of Cincinnati, Cincinnati, Ohio, authority on epidemiology, bacteriology, and pathology.

The *Interlude (Present Status)* was next discussed by the following:

Dr. Per K. Frolich, Deputy Chief Chemical Officer for Scientific Activities;

Brig. Gen. William R. Currie, Assistant Chief Chemical Officer for Planning and Doctrine.

In covering the *period 1958 on*, two alternatives were offered:

1) A projection of the Chemical Corps as far into the future as possible, via the imagination and concepts of the participants. This included concepts of agents, munitions, exotic chemicals and fuels, meteorology and control of weather, protective items as well as control of toxicological effects by immunization, or other means.

(2) Emphasis upon Chemical Corps contributions to humanity and better living resulting from Chemical Corps research and development.

The panelists covering the above period were the following:

Dr. Charles G. Overberger (see discussion of *period 1920-1938*, above).

Dr. D. B. Dill, Deputy Director of the Medical Research Directorate, Chemical Warfare Laboratories, Army Chemical Center;

Dr. Leroy D. Fothergill, Scientific Advisor to the Commanding Officer, U.S. Army Biological Warfare Laboratories, Fort Detrick, Frederick, Maryland;

Dr. Alsoph H. Corwin, Professor of Organic Chemistry, The Johns Hopkins University;

Mr. George Milly, Senior Physical Scientist in Operations Research Group, and

Dr. Winfred O. Milligan, Professor of Physical Chemistry, Rice Institute, Houston, Texas, Chairman of the Committee (ACS) Advisory to the Chemical Corps.

The four subcommittees of the Committee (ACS) Advisory to the Chemical Corps held meetings on May 20.

Public Relations: Dr. Walter J. Murphy, Chairman. Dr. Murphy is editorial director of the *Chemical and Engineering News*, and other chemical news media.

Industrial Relations: Dr. Ernest H. Volwiler, Chairman. Dr. Volwiler (recent Priestley Medal winner, the highest award in chemistry), was president and general manager of Abbott Laboratories, and is now chairman of the board.

Research: Dr. Charles G. Overberger, chairman of the Research subcommittee.

Educational: Dr. Alsoph H. Corwin, Chairman.

At a dinner meeting on 19 May, Dr. Price received a citation presented by Brig. Gen. Walmsley, signed by Maj. Gen. William M. Creasy, which read as follows:

"For meritorious service as a Consultant to the U.S. Army Chemical Corps, Army Chemical Center, Maryland; as a member of the American Chemical Society Committee Advisory to the Chemical Corps from its activation in 1947; as a member of its Educational Subcommittee until 1955; and as Chairman of the American Chemical Society Committee Advisory to the Chemical Corps from 1955 to date. Dr. Price has rendered outstanding performance through his leadership in programs for effective utilization and treatment of scientific and technical manpower within the Chemical Corps, and programs on dissemination of information outside the Chemical Corps which have promoted the stature of the Corps with the public, industry, and the chemical profession. His accomplishments reflect great credit upon himself and upon the Chemical Corps and are an inspiration to his associates.

/s/ WILLIAM M. CREASY
Major General, USA
Chief Chemical Officer

DATE: May 14, 1958

IV

STINK BALLS, FIRE RAIN, AND SMOKE POTS—CHEMICAL WEAPONS IN 1825

By WYNDHAM MILES
U. S. Army Chemical Corps Historical Office

JAMES CUTBUSH'S *System of Pyrotechny* is a collector's item. In twenty years of book buying I have seen only four copies offered for sale by antiquarian book dealers. Only one of those was in good condition, in the original boards, and it went for $25.00. My copy is shabby, badly foxed, with the covers loose and the fly leaves missing, but in spite of its defects the dealer wouldn't take less than $10.00.

Cutbush died in 1823, when he was Professor of Chemistry and Mineralogy at West Point. His manuscript was not ready for publication, but Cutbush's widow got another chemist named Franklin Bache (a grandson of Benjamin Franklin) to edit the work, and the cadets chipped in to pay the printer. The book appeared in 1825, dedicated by Clara Cutbush "To the Corps of Cadets of the United States Military Academy."

The *Pyrotechny* was the first American treatise on fireworks and ordnance. Instructors at the Academy used it as a text and reference for many years. When we open the book and start reading, it is like stepping into a different world. In 1825 breech-loading, rifling, high explosives, recoil mechanisms, smokeless powder,

A

SYSTEM OF PYROTECHNY,

COMPREHENDING THE THEORY AND PRACTICE, WITH THE APPLICATION OF CHEMISTRY;

DESIGNED FOR EXHIBITION AND FOR WAR.

IN FOUR PARTS:

CONTAINING AN ACCOUNT OF THE SUBSTANCES USED IN FIRE-WORKS; THE INSTRUMENTS, UTENSILS, AND MANIPULATIONS; FIRE-WORKS FOR EXHIBITION; AND MILITARY PYROTECHNY.

ADAPTED TO THE

MILITARY AND NAVAL OFFICER, THE MAN OF SCIENCE, AND ARTIFICER.

BY JAMES CUTBUSH, A. S. U. S. A.

LATE ACTING PROFESSOR OF CHEMISTRY AND MINERALOGY, IN THE UNITED STATES MILITARY ACADEMY—MEMBER OF THE AMERICAN PHILOSOPHICAL SOCIETY—CORRESPONDING MEMBER OF THE COLUMBIAN INSTITUTE—MEMBER OF THE LINNÆAN AND AGRICULTURAL SOCIETIES OF PHILADELPHIA—LATE PRESIDENT OF THE COLUMBIAN CHEMICAL SOCIETY, AND VICE-PRESIDENT OF THE SOCIETY FOR THE PROMOTION OF A RATIONAL SYSTEM OF EDUCATION, &c. &c. &c.

PHILADELPHIA:
PUBLISHED BY CLARA F. CUTBUSH
1825

Title Page of rare book written by early American chemist and professor at West Point dedicated by his widow to the Cadets.

This article is the fourth in a series by Dr. Miles; the next will appear in an early issue. →

elongated shells, and other characteristics of modern ordnance were unknown. We find, instead, Murdering Marrons, Petards, Thundering Barrels, Pyrophores of Defense, Infernal Machines, Marine Incendiary Kegs, Floating Rocket Carcasses, and other outlandish contraptions.

Several of the devices in Cutbush's armory were the primitive ancestors of our chemical, incendiary and smoke weapons. Take, for example, a missile that he calls the Stink Ball, intended for harassing enemy troops. A burning stink ball gave off sulfur dioxide as well as an assortment of nauseating gases:

Stink Balls are prepared with a composition of mealed powder, rosin, saltpetre, pitch, sulphur, rasped horses' and Asses' hoofs, burnt in the hoof, assafoetida, seraphim-gum, stinking herbs, &c. made up into balls in the same manner as light balls, according to the size of the mortar, out of which they are to be thrown.

What a mixture! Enough to make a man who inhaled the smoke wish he were dead.

I recall a mention of Stink Balls in the records of the Civil War. On 10 June 1864, Brigadier General W. N. Pendleton, Chief of Artillery, Army of Northern Virginia, wrote the following lines to Lieutenant Colonel Briscoe G. Baldwin, Chief of Ordnance:

I saw noticed in a recent paper a stink-shell, and it seems to me such missiles might be made useful to some extent at least. We have a few howitzers, chiefly 12-pounders, which can be used somewhat as mortars. They can throw shells occasionally in or near the enemies trenches. The question is whether the explosion can be combined with suffocating effect of certain offensive gases, or whether apart from explosion such gases may not be emitted from a continuously burning composition as to render the vicinity of each falling shell intolerable. It seems at least worth a trial.

The letter passed to Lieutenant Colonel W. Le Roy Broun, who answered laconically: "Stink balls, none on hand; don't keep them; will make if ordered." The sixty-four dollar question is, did General Pendleton order and use them?

The Stink Ball mixture was also used on a weapon called the Stink Fire Lance for fighting off sappers. Cutbush's words leave no doubt that poisonous gases were at work:

This lance (Lance à feu puant of the French) is prepared in the same manner as stink-pots, and is principally used by miners. When a miner or sapper has so far penetrated towards the enemy, as to hear the voices of persons in any place contiguous to his own excavation, he first of all bores a hole with his probe, then fires off several pistols through the aperature, and lastly forces in a lance à feu puant. He takes care to close up the hole on his side, to prevent the smoke from returning towards himself. The explosion and fetid gas and vapour, which issue from the lance, and remain on the side of the enemy, infect the air so much, that it is impossible to approach the quarter for three or four days. Sometimes, indeed, they have had such instantaneous effect, that, in order to save their lives, miners, who would persevere, have been dragged out in an apparent state of suffocation.

Cutbush's Suffocating Pot was more mild, giving off nothing but oxides of sulfur and nitrogen to gas the enemy:

The suffocating pot is another contrivance, as its name expresses, to produce suffocation; and, as the materials consist only of sulphur and nitre, the gas which principally produces this effect is the sulphurous acid.

Composition for Suffocating Pots
Sulphur, 6 parts
Nitre, 5 parts

Cutbush does not cite any instances of the use of suffocating pots in warfare, but it is not difficult to see that it could have been called upon in special situations, such as harassing the enemy or in driving him from small fortified positions.

Judging by the number of incendiary devices in the *Pyrotechny*, this field must have been the happy hunting ground for ingenious ordnance experts. Cutbush mentions Fire Balls, Incendiary Balls, Powder Bags, Fire Ships, Greek Fire, Incendiary Bombs, Inflammable Darts, Firebrands, Fire Flasks, Inflammable Balls, and Incendiary Rope. These devices may not have been too practical, but some of them sound intriguing. Consider the Fire-Rain:

The fire-rain is an incendiary fire-work, and calculated, like other incendiaries, for firing the houses of a besieged place or city, which are covered with shingles, laths, stubble, or reeds. Besides several other compositions, designated by artificers, that of fire-rain was so called from its supposed resemblance to a shower of rain.

To prepare this composition, the following method is used: We take 24 parts of sulphur, and melt in a copper, or iron pot, over live coals without flame, and then throw in 16 parts of saltpetre, and mix it with an iron spatula, to incorporate the whole. The pot is now removed from the fire, and when the composition is become rather cold, stir into it 8 parts of grained powder. The composition is then poured on a marble slab, or metallic plate, where it is allowed to cool. It is then broken into pieces of the size of a walnut, which, when used, is interspersed with quick match, covered with gunpowder, and put into shells or bombs.

Although ordnance experts gave much thought to the development of incendiaries, these weapons never lived up to the hopes of their inventors. It is difficut to find a battle or siege of olden times in which incendiaries played an important part. The armies lacked two things that have brought about the success of incendiaries in modern warfare, the airplane to deliver incendiaries, and an efficient missile for planes to deliver.

One incendiary weapon, however, that Cutbush dwells upon for some length may surprise those who think that rockets are new. He devotes many pages to Signal Rockets, Sky-Rockets, Rocket Light-Balls, and similar devices. He considered Congreve's rocket of particular importance:

The Congreve rocket is a new species of war-rocket, invented by Sir William Congreve. This incendiary rocket drew the attention of the European nations, after the attack of the British on Copenhagen; where, we are informed, they did incredible execution. This rocket may be considered to be a carrier of fire. Their effect, however, in the Chesapeake, and elsewhere, during the late war, was very trifling. They seemed, in fact, little calculated to injure and more to intimidate. They differ from the common rocket as well in their magnitude and construction, as in the powerful nature of their composition; which is such, that without the encumbrance of any ordnance, (the rocket containing the propelling power wholly within itself), balls, shells, case-shot and carcasses, may be projected to the distance of one thousand to three thousand yards. The principle of projectile force is so greatly increased, as not only to triple the flight of small rockets so formed, but also to allow of the construction of rockets of such dimensions, as, on the ordinary principles of combination, would not even rise from the ground, and of such powers of flight and burthen, as have hitherto been considered altogether impracticable.

On the basis of this increase of power, Congreve has succeeded in making this rocket. They are formed of various dimensions, as well in length as in caliber, and are differently armed, according as they are intended for the field, or for bombardment and conflagration; carrying in the first instance either shells or case shot, and in the second, for the purpose of destroying shipping, buildings, stores, &c. a peculiar species of composition, which never fails of destroying every combustible material with which it comes in contact. The latter are called carcass-rockets, and were first used at Boulogne in 1805, after many experiments, which were made by Congreve, at Woolwich. The attack in 1806 was merely desultory, in which not more than 200 rockets were fired. The town was set on fire by the first discharge, and continued burning for near two days. After the affair at Copenhagen, which established their reputation, it appears that a committee of officers, who had witnessed their effect in that bombardment, pronounced them to be "a powerful auxiliary to the present system of artillery."

At the seige of Flushing, they appear to have been used with success, and general Monnet, the French commandant, made a formal remonstrance to Lord Chatham respecting the use of them in that bombardment. The rocket system was also tried with success, and the crown prince of Sweden was the first general, who bore testimony to their effects in this service. At the memorable battle of Leipzig, they proved, we are informed, a powerful weapon, and also, when the British army under Wellington crossed the Adour. In 1814, a rocket-corps was established in the British service.

It was Congreve's rocket that the British fleet showered on Fort McHenry during the war of 1812 and which led Francis Scott Key to recall "the rocket's red glare" in The Star Spangled Banner.

Smoke was seldom used in Cutbush's day, and he does not spend many words on smoke mixtures. Those he mentions produced smoke by combustion of organic materials:

H. A. KUHN
Consultant
Chemical & Industrial
Reports • Surveys
1426 G Street N.W.
Washington 5, D. C.

We may mention [a] composition, to produce smoke, which is used either in pots, or balls. Hence, the smoke-pot, and smoke-balls. The following is the composition:

Grained-powder,	**10 lbs.**
Nitre,	**2 "**
Pitch,	**4 "**
Sea-coal,	**3 "**
Tallow,	**1 "**

The coal and pitch produce the smoke, and the gunpowder and nitre promote the combustion, and, with the tallow render the product of combustion more offensive.

All of us who have seen pitch burn would not expect the smoke from the above mixture to have much obscuring power, but the burning pitch and tallow undoubtedly smelled—to use Cutbush's words—"offensive."

Cannon balls filled with smoke mixture were prepared in the following manner:

Smoke balls are composed of the same substances as carcasses and lightballs, with this difference, that they contain five to one of pitch, rosin, and sawdust. This composition is put into shells made for the purpose, having four holes to let out the smoke. Smoke balls are thrown out of mortars and continue to smoke from twenty-five to thirty minutes.

Military men were on the right track when they sensed the protective value of smoke, but another century had to pass before efficient smoke devices were perfected, and the usefulnes of smoke was proved in battle.

In writing his *Pyrotechny,* Cutbush could not have dreamed that an entire service of the Army would one day concern itself with military devices that were of so little importance in 1825. The chemical, incendiary, and smoke devices of Cutbush's time are like toys when compared to modern weapons, but they were the things from which the Chemical Corps grew.

Of Cutbush the man we know practically nothing. He was a native of Philadelphia. He became one of the best chemists in the United States—apparently without any formal training, for there is no record of his attendance at an American college. He was president of the Columbian Chemical Society (the first chemical society to issue memoirs) from 1812 to 1815. Thomas Jefferson and Cutbush were at least acquaintances and perhaps friends, judging by several Jefferson letters in the Library of Congress. Cutbush wrote several books, among them the *Philosophy of Experimental Chemistry* (1813), the first textbook of chemistry by an American. He went into the Army as Assistant Apothecary-General in 1814, and later served at West Point as Post Surgeon and acting Professor of Chemistry and Mineralogy. He died young, and after his death the cadets erected over his grave a monument bearing this inscription:

Sacred to the memory of Dr. James Cutbush, Member of the American Philosophical Society, Late Surgeon, U.S. Army and Professor of Chemistry at the U.S. Military Academy, West Point, N.Y., who departed this life December 15, 1823, aged 35 years. An honorable tribute of respect from his grateful pupils.

References

The only biography of Cutbush is Edgar F. Smith's *James Cutbush, an American Chemist, 1788-1823* (Philadelphia, 1919). This small book deals mainly with Cutbush's writings, since Smith was not able to discover much about Cutbush's life.

The correspondence between General Pendleton and Colonel Broun quoted above may be found in *The War of the Rebellion, Official Records of the Union and Confederate Armies,* Vol. 36, Part 3, p. 888.

CHEMICAL CORPS NEWS

GEN. MARSHALL STUBBS, CHIEF CHEMICAL OFFICER

General Marshall Stubbs is the new Chief Chemical Officer of the Army. Orders naming him for this position, effective September 1, and carrying his promotion from Brigadier General to Major General, were issued by the Department of the Army on August 29.

General Stubbs, the 11th Chief of the Chemical Corps since its establishment as a separate branch of the Army, has succeeded Major General Wm. M. Creasy, who retired on August 31.

The orders appointing General Stubbs also provided his relief from his last duty assignment as Commanding General First Logistics Command, Fort Bragg, N.C.

General Stubbs was born in Superior, Nebraska, in 1906. He was graduated from West Point in 1929 and commissioned in the Infantry; transferred to the Chemical Corps in 1934. In World War II he served in the European Theater with the Eighth and Ninth Air Forces and later as G-4 of the Advance Base Section, ComZ. He was made a Brigadier General in 1954. His last previous Chemical Corps assignment was Commander of the Materiel Command and the Army Chemical Center, Maryland.

COL. SULLIVAN PROMOTED TO BRIGADIER GENERAL

Colonel William E. R. Sullivan, Deputy Chief Chemical Officer, Washington, D.C., has been promoted to the grade of Brigadier General. Orders announcing this promotion were issued on August 29.

General Sullivan, 52, commanded an Engineer Battalion in World War II. He was integrated in the Regular Army in 1946 and transferred to the Chemical Corps. He has a Business Administration degree from Harvard.

GEN. CREASY JOINS LUMMUS COMPANY UPON RETIREMENT

Major General William M. Creasy, who retired as Chief Chemical Officer of the Army on August 31, has joined The Lummus Company, 385 Madison Avenue, New York as Vice President. He will serve as Director of The Lummus Engineering Development Center. The announcement was made by Mr. J. F. Thornton, President of the firm of engineers and constructors.

General Creasy was graduated from the United States Military Academy in 1926. He has an M.S. degree in Chemical Engineering Practice from M.I.T. obtained in 1936 and is a registered professional engineer in New York, Maryland and the District of Columbia. He is a member of the American Institute of Chemical Engineers, American Chemical Society, Washington Society of Chemical Engineers, Armed Forces Chemical Association, Association of the U. S. Army, and the Newcomen Society of America.

During World War II, General Creasy spent three years in the China-Burma-India theater of operations, serving as Chief of Plans Division, Theater Headquarters; Deputy Commander, Services of Supply in Western China; and Senior Logistical adviser of the U.S. Military Mission to China.

General Creasy's awards include the Distinguished Service Medal, Legion of Merit, Bronze Star Medal and a number of foreign decorations.

BRIG. GEN. CURRIE RETIRES

Brigadier General William R. Currie, Assistant Chief Chemical Officer for Planning and Doctrine of the Army Chemical Corps, retired on July 31 after more than thirty years' active military service.

Born at Fort Leavenworth, Kansas, he is the son of the late Brigadier General Dennis Hadley Currie and Mrs. D. H. Currie who now resides in Fresno, California. He was graduated from the United States military Academy in 1928 and served in the Infantry until he transferred to the Chemical Corps in 1950.

During World War II he commanded a task force in Liberia and as such had the additional duty of being military adviser to the President of Liberia.

In the Chemical Corps he has been active in research and developent programs, and also served as Commanding Officer of the Training Command. He was promoted to Brigadier General in July 1955.

General and Mrs. Currie plan to live in Hyattsville, Maryland.

COL. GUILD AWARDED LEGION OF MERIT ON RETIREMENT

Col. Walter A. Guild, who has been serving as Liaison Officer with the U.S. Public Health Service, retired from active service on July 31. At a ceremony in his honor held at the Department of Health, Education and Welfare, on July 29, he was decorated with the Legion of Merit with Oak Leaf Cluster by Maj. Gen. William M. Creasy, Chief Chemical Officer.

Acting Surgeon-General John D. Porterfield, of the Public Health Service, stated that Colonel Guild had rendered invaluable assistance to both that Service and the Department of the Army.

Colonel Guild, who has been a member of the Chemical Corps since 1924, served during the war in the Mediterranean and European Theaters, and afterward as Executive Officer of Plans, Training and Intelligence Division in the Office of the Chief Chemical Officer and later as Chemical Officer, First Army.

Colonel and Mrs. Guild will reside at their Cape Cod home at Orleans, Mass.

COL. HAYES MADE WAR COLLEGE INSTRUCTOR

CARLISLE BARRACKS, PA.—Col. John J. Hayes, Chemical Corps, a June graduate of the U.S. Army War College here, has been retained as a member of the faculty at the Army's senior educational institution. Col. Hayes is a 1935 graduate of Washington University (St. Louis, Mo.) and obtained his M.S. and Ph.D. from Catholic University, Washington, D.C. A veteran of 18 years active military service, he fought through five campaigns in Europe during World War II. Before attending the 10-month course at the Army War College, Col. Hayes commanded Fort Detrick, Md.

MR. KRACKOW, AIR POLLUTION EXPERT TO DIRECT NEW PROGRAM IN FLORIDA

EDGEWOOD, MD.—Mr. Eugene H. Krackow, an expert in the field of air pollution and chief of the Toxicology Division, Chemical Warfare Laboratories, Army Chemical Center, has been granted a year's leave of absence to become director of the Resources Research Corporation at Lakeland, Florida.

He will conduct a program of studies to determine the nature of fumes and dust from factory areas and their effects on adjacent farm lands, citrus crops, and cattle.

At the Toxicology Division, Mr. Krackow was responsible for conducting toxicity studies and research on hazards to health caused by military chemicals, and on the safe handling of chemicals used by operational elements of the Department of Defense.

Mr. Krackow has been with the Corps for sixteen years and is a consultant of the U.S. Public Health Service. An alumnus of Johns Hopkins University, he studied also at Columbia University and the Edinburgh College of Medicine.

TO ARMY WAR COLLEGE—Col. Frank M. Arthur, who, for several years, has been Chief of the Career Management Division, Office o fthe Chief Chemical Officer, has been designated to attend the next course at the Army War College, Carlisle Barracks, Pa.

Colonel Arthur had extensive experience in the Far East in World War II as Division and later as Corps Chemical Officer. He has a Master's degree in Business Administration from George Washington University.

NEW PERSONNEL CHIEF——Col. Claude J. Merrill has taken over from Colonel Arthur as Chief of Career Management Division, Office of the Chief Chemical Officer.

Colonel Merrill, who has a Bachelor's degree in Engineering from Johns Hopkins University, is a graduate of the Industrial College of the Armed Forces and other Service schools. He served in the European Theater in World War II. His most recent assignment was Deputy Commander of the Chemical Corps Materiel Command.

LIAISON DUTY WITH U.S. P.H.S.—Col. Victor C. Searle, who, for the past few years, has served as Assistant Commandant of the Industrial College of the Armed Forces, has replaced Col. Walter A. Guild (retired July 31) as Liaison Officer of the Chemical Corps with the Public Health Service in the Department of Health, Education and Welfare.

COL. MUTH IS NEW HEAD OF ENGINEERING COMMAND

EDGEWOOD, Md.—Colonel Roy W. Muth, former Chemical Officer at Headquarters Continental Army Command, Fort Monroe, Virginia, now heads the Chemical Corps Engineering Command at Army Chemical Center. He succeeds Colonel William J. Allen, Jr., who has been assigned to command Rocky Mountain Arsenal, Denver, Colorado.

Colonel Muth, a 1930 graduate of the U.S. Military Academy, joined the Chemical Corps in 1936. He has a Master's degree in Business Administration from Harvard. During World War II, he served in France and Germany as commander of a chemical mortar battalion, as Chemical Officer, VIII Corps, and later as Chemical Officer, Ninth Army.

ROCKY MTN. ARSENAL PRAISED FOR FIRE PREVENTION RECORD

For the third consecutive year Rocky Mountain Arsenal has received a Certificate of Merit from the National Fire Protection Association for its achievement in Fire Prevention. This certificate was presented by Brig. General Harold Walmsley, Commanding General, U.S. Army Chemical Center and Chemical Corps Materiel Command, Army Chemical Center, Maryland, to the Arsenal Commander in ceremonies held at the Headquarters Building, Rocky Mountain Arsenal on 28 May. Captain Robert E. Depler, Fire Marshal, and James E. Hubbard, Fire Chief, both received individual citations from the Post Commander.

The Arsenal has incurred no fire loss during a period of 23 months. The record is attributed to extensive fire prevention educational and training programs conducted at the Post.

ACC SOLDIER SCIENTISTS AGAIN GIVE SCHOLARSHIP

EDGEWOOD, MD.—A group of young soldier-scientists stationed at the Army Chemical Center have since 1951 made it possible for a Harford county high school graduate to attend a college of his, or her, choice. They are inductees, all college graduates themselves holding degrees from B.A. to Ph.D., most of them privates. They belong to the Army's Scientific and Professional Personnel program which enables them to perform the same type of work in uniform as they performed in civilian life.

This year's scholarship, which amounted to $675, was awarded to Harris J. Fisher, a graduate of North Harford High School, one of sixteen applicants.

Harris J. Fisher (left) receives the Army Chemical Center Enlisted Specialists Club scholarship award from Private First Class Walter J. Jacobson, president of the club, as Mr. William H. Pyle, principal of the North Harford High School, where Harris was graduated, looks on.

ENGINEER OFFICER TOPS CBR COURSE

VAIHINGEN, Germany—An officer of Company C, 37th Engineer Battalion in Mannheim Kafertal, has been commended for achieving the highest average in the CBR Officer Course, Class Number 4, at Seventh Army's CBR School.

Major James S. Dearth, Commandant of the Chemical, Bacteriological and Radiological School, cited First Lieutenant James R. Strickland for his course score of 97.9 per cent.

Seventh Army Commander Lieut. General Bruce C. Clarke added congratulations, saying, "Your demonstrated capacities and devotion to duty should contribute greatly to your future success in the military service."

EDGEWOOD TEAM PERFECTS GAS MASK LEAKAGE TESTING METHOD

In the testing of gas masks for leakage the Chemical Corps has long struggled with the problem of providing a head-piece to hold the mask so as to have a perfect seal around the perimeter of the face-piece of the mask. Recently a team consisting of Mr. E. B. Kirkpatrick, project engineer, of the Quality Assurance Technical Agency, and Mr. Charles F. Novak, Chief of the Design Division of the Agency, came up with a satisfactory solution after two years work. This is a head-piece made of smooth cast aluminum.

When the mask is sealed on the head-piece a slight negative pressure is created inside the mask. The outside of the mask has been sprayed and if there are any leaks in the face-piece an aerosol from the sprayed-on substance will be drawn through the hole and the leak thus detected by a sensitive electronic device. Present standards require the face-piece to be 100% leak-proof.

AUTOMATION SPEEDS CHEMICAL CORPS SUPPLY OPERATIONS

EDGEWOOD, Md.—In order to complement its pentomic concept of swift and highly mobile striking forces the Army has developed a largely automated, worldwide inventory management system to speed up supply support of its many widely scattered installations both in the U. S. and overseas.

Among the agencies of the Army now using this system is the U.S. Army Chemical Corps Materiel Command with headquarters at Army Chemical Center, Maryland.

Prior to the introduction of the new system, when an installation needed a Chemical Corps item it would

(Continued next page)

Palladium Ammonium Chloride, Palladium Black
Diammine [illegible] Palladium [illegible] ide Dian
oxime, [illegible] Monosu
Palladium Oxide, [illegible], Palladous
Aldehyde, Palmitoleic Acid, Palmitoyl Chlori
[illegible], Pantothenol, Pant
[illegible] Pectinolytic Enzymes, Pellidol, [illegible],
Pentaacetyl-d-glucononitrile, [illegible]-a-
[illegible] Pent
[illegible] Acid, Pentadecylic [illegible] eryt
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THE HISTORICAL CORNER

By **BROOKS E. KLEBER**
U. S. Army Chemical Corps, Historical Office

The Deactivation Of The 42nd Chemical Laboratory

THE deactivation of the 42nd Chemical Laboratory on 15 June 1958 closed another chapter in the long and distinguished history of a unit which saw duty throughout World War II and during the period 1954-1958.

Activated at Edgewood Arsenal on 15 May 1941 as the 3d Chemical Company (Laboratory) the unit was enroute to the Far East when the Japanese attacked Pearl Harbor. Diverted to Brisbane, Australia, the Chemical laboratory company began its long overseas tour which wasn't to end until nearly five years later.

For some time the 42nd (so designated in March 1942) was the only military laboratory in the Pacific area and, as such, performed jobs not only for the CWS but for other elements of United States forces. These non-CWS duties involved such diverse jobs as the search for an antidote for the "sting" of a poisonous tree and the analysis of blood samples and unknown chemicals (for the Medical Corps); the development of an insect repellant skin dye and the analysis of embalming fluid (for the Quartermaster Corps); the analysis of water and photographic solution (for the Corps of Engineers); the examination of defective bomb fuzes and mortar propellants (for Ordnance); the analysis of aviation gasoline, engine coolants, and fuel line deposits (for the Air Corps); the examination of cigarettes suspected of containing cordite and narcotics (for the Counter Intelligence Corps); and the testing of gas mask canisters and of boiler expansion plugs (for the U.S. Navy).

These, of course, were in addition to the normal CWS duties such as the examination of liquid vesicant detector paint, the surveillance of bulk mustard and mustard-filled bombs, the manufacture of gas identification sets, the development and modification of CWS munitions, and the analysis of captured Japanese equipment.

In June 1945 the 42d Chemical Laboratory Company moved from Australia to the Philippines. Here it continued its duties until January 1946 when it was transferred, less personnel and equipment, to Hawaii. The unit was reorganized in July 1946 at Oahu, only to be deactivated three months later. During its long service in the Pacific the 42d earned battle stars for the Philippine Islands and Luzon Campaigns.

On 15 November 1954 the 42d Chemical Laboratory was reactivated. Organized with the personnel and equipment of the recently deactivated 390th Laboratory, the unit remained at the Army Chemical Center from that date until the recent action on 15 June.

Although this second tour of duty took place in time of peace and in the zone of the interior, the 42d's mission was not merely training for possible employment overseas. The main job of the 42d Chemical Laboratory, done in support of the Chemical Corps Intelligence Agency, was the preparation of evaluation reports on foreign material.

This brief note on the history of the 42d Laboratory is in salute to a unit which has served the Chemical Corps long and well.

CHEMICAL CORPS NEWS

(Continued from page 39)

mail its requisition to one of several supply depots. In certain cases this resulted in delays.

Under the new system, requisitions are no longer mailed to the depots but are forwarded to the Chemical Corps Materiel Command Headquarters which issues shipping instructions to the appropriate depot. Rapid punch card stocks records are kept up-to-date daily by using an automatic device called the Data Transceiver.

MRS. ROY W. MUTH

ARMY CHEMICAL CENTER, Md.—Mrs. Doris Muth, wife of Colonel Roy W. Muth, who recently assumed command of the Chemical Corps Engineering Command, died July 18 at the Army Chemical Center. In addition to her husband, Mrs. Muth is survived by three children: Lieutenant Roy M. Muth, Jr., stationed in Munich, Germany; Miss Jane Muth, and Miss Gretchen Muth.

Funeral services were held July 21 at the Post Chapel. Burial was in the Post Cemetery.

DR. VLADIMIR A. GORDIEYEFF

ARMY CHEMICAL CENTER, Md.—The Army Chemical Corps research program suffered a severe blow with the death, on April 30, 1958, of Dr. Vladimir Alexander Gordieyeff, Directorate of Medical Research, Chemical Warfare Laboratories. Dr. Gordieyeff, who was Chief of the Basic Toxicology Branch, died from injuries received in an automobile accident on April 9.

Dr. Gordieyeff was born in Moscow in 1909. He held degrees from the University of Warsaw, and the University of Leipzig, and had done Postdoctoral studies at the University of Prague and the University of Vienna.

During the defense of Warsaw in 1939, Dr. Gordieyeff was a sergeant in the Polish Armed Forces. Taken prisoner by the German Gestapo, he was liberated by the American Forces in 1945, came to the United States in 1946 and was naturalized in 1951.

Dr. D. B. Dill, Deputy Director of Medical Research, said of Dr. Gordieyeff—"He was one of our most versatile scientists. . . . His contributions in the field of aerosols have brought nationwide attention to his work. As a scientist and as a personality, we will feel his absence keenly."

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